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DISASTER ASSISTANCE (FLOOD MITIGATION)

NATO Committee on the Challenges of Modern Society
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This report is on the meeting of Flood Experts of NATO and their work. The panels discussed: 1. Hazard Reduction, 2. Prediction and Warning, 3. Emergency Operations 4. Rehabilitation Operations, and 5. The Roles of Governments, Universityies, Industry and Voluntary Organizations.

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DISASTER ASSISTANCE

(Flood mitigation)

"The Venice meeting of flood experts, under the aegis of the Committee on the Challenges of Modern Society, set a significant precedent of international interest and co-operativeness in the field of natural disasters. Around the world we shall be better prepared to meet and respond to natural tragedies because of the demonstrated willingness to continue to work together. This work will surely contribute to the establishment of a better environment for our peoples."

George M. GRACE
Co-Chairman of the Meeting (US),
Director of Field Operations,
Office of Emergency Preparedness,
Executive Office of the President

"Sono stati individuati numerosi ed essenziali punti di interesse comune per i quali è necessario proseguire e perfezionare un'azione concorde in campo internazionale specie per quanto riguarda la previsione delle alluvioni, l'approfondimento della conoscenza dei fenomeni e delle tecniche intese a ridurne le conseguenze dannose e l'attuazione di un'aiuto coordinato rapido ed efficace ai Paesi colpiti.

In tal modo, dalle gravi e dolorose esperienze degli eventi alluvionali, potranno trarsi impulsi ed indirizzi che valgano a ridurre, come è stato nelle intenzioni del Convegno, le conseguenze negative delle avversità meteorologiche, a vantaggio dei nostri Paesi e di una società più civile e illuminata da un più vivo ed operante senso di solidarietà."

Giuseppe MIGLIORE
Co-Chairman of the Meeting (Italy)
Prefetto, Directore generale della protezione civile
Ministero del Interno

CCMS No. 2

MEETING OF FLOOD EXPERTS HELD UNDER THE AEGIS OF THE COMMITTEE ON THE CHALLENGES OF MODERN SOCIETY OF THE NORTH ATLANTIC TREATY ORGANIZATION

VENICE, 20TH TO 23RD OCTOBER, 1970

I. INTRODUCTION

In accordance with the North Atlantic Council's decision, in January 1970, to sponsor a Disaster Assistance Project under the aegis of the Committee on the Challenges of Modern Society of the North Atlantic Treaty Organization, flood experts from 12 NATO countries met in Venice from 20th to 23rd October, 1970. In addition to the 90 persons sent by NATO member governments and the NATO International Staff, there were observers from the Commission of European Communities, the International Relief Union and the Sovereign Order of Malta.

2. Italy, as co-pilot and host, and the US as pilot country, provided the Co-Chairman for the meeting, Prefetto G. Migliore, General Director for Civil Protection, Ministry of the Interior, and Mr. George M. Grace, Assistant Director for Field Operations, Office of Emergency Preparedness, Executive Office of the President, respectively.

3. On the final day of the meeting, the delegates heard addresses by the Honourable Daniel P. Moynihan, Counselor to the President of the United States and Senator Giovanni Zonca, Under Secretary of State for Scientific and Technological Research, Government of Italy.

II. CONDUCT OF MEETING

4. Following the formal opening of the meeting, Eng. Delle Chiaie of Italy gave a presentation on the history of flooding. The meeting was then devoted to presentations and panel discussions of the following subjects:

I. Hazard Reduction
II. Prediction and Warning
III. Emergency Operations
IV. Rehabilitation Operations
V. The Rôles of Governments, Universities, Industry and Voluntary Organizations.

5. Prior to the meeting, background papers had been distributed to the delegations. In addition, a number of presentations were made at the meeting, some accompanied by films and slides. Following the presentations, the panels discussed each topic. Each of the five panel Chairmen prepared a report reflecting the panel's discussions, both in the plenary sessions and in subsequent executive sessions, and presented a series of recommendations for actions to be taken by governments.

6. In addition to the recommendations developed by the panels, the conference Co-Chairmen presented three recommendations. Both the panel recommendations and those of the conference Chairman are given below.

III. OBSERVATIONS

7. The meeting of flood experts set a significant precedent. Since a flood rarely affects more than one nation at a time, there has been only occasional international co-operation in this field. Unlike other topics that the CCMS has addressed, there are neither the incentives of international commerce nor of strong, widespread and sustained public concern, such as those that have lent impetus to activities in fields such as automotive safety and air and water pollution. Beyond this, there are no existing international organizations specifically charged with addressing the problems of flooding.

8. The personal contacts made at the meeting were particularly valuable in that they acquainted the participants with the organizational structures and the physical methods employed by the governments of other NATO countries in dealing with floods.

9. As will be noted below, the experts' recommendations for government actions reflect the lack of previous international undertakings in the flood area, and look to the establishment of information exchange mechanisms and to future co-operation based on the beginnings made at Venice.

IV. CHAIRMEN'S RECOMMENDATIONS

10. The Co-Chairmen, having noted with approval the specific recommendations of the five panels of experts, have drawn up the following broad recommendations. These recommendations, which in each case cover areas of responsibility of several of the panels, are:

(a) That interested NATO governments give immediate and increased attention to the problem of forecasting water levels in connection with rapid (flash) flooding, river flooding and coastal flooding. In working toward this objective, it is suggested that governments support the improvement of lower atmospheric forecasting and the development of automated hydrologic networks. Information on these advancements should be subsequently disseminated to interested NATO nations.

(b) That NATO establish a Disaster Information Centre to provide for a continuing exchange of scientific and technical information dealing with flooding. At a minimum, the centre would be a repository in which scientific and technical information and major disaster records would be received from nations and catalogued. A list of materials stored at the centre, with a brief description of contents would be circulated periodically to nations. Further, it is recommended that arrangements be made in the near future to enable exchanges of scientific, technical and operational staff among Alliance members. The pilot and co-pilot countries will take steps to foster such exchanges among interested governments.

(c) That, consistent with the disaster assistance procedures now under consideration within NATO, arrangements could be made to co-ordinate international assistance in time of flooding. Such arrangements should facilitate the collection and dissemination of information on floods and should make possible the timely dispatch of experts and operational specialists, on request, to the flood-stricken nation.

V. PANEL RECOMMENDATIONS

11. Panel I - Hazard Reduction

(a) That interested governments move promptly to improve and expand those data collection programs that relate to the study of floods and to their mitigation.

(b) That interested governments undertake detailed planning programs for regions that have been identified as high flood frequency areas.

(c) That interested governments encourage the use of multi-purpose flood hazard reduction structures. Such structures should be environmentally compatible and, to the extent feasible, provide such benefits as recreational facilities, drinking water and industrial water supplies, as well as flood hazard protection.

(d) That governments of countries with flooding problems adopt comprehensive flood plain management programs.

(e) That interested NATO member governments sponsor seminars on the specific topics listed above in paragraphs (a) through (d). If possible, such seminars should be held within existing organizations. If no existing organizations are found appropriate for such meetings, member governments or the NATO Science Committee should be asked to sponsor them.

12. Panel II - Prediction/Warning

Interested member governments should sponsor exchanges of persons versed in automation and in sophisticated sensing and monitoring techniques. Such exchanges should be arranged so as to allow the more technically experienced nations to share their techniques on flooding problems with less technically advanced countries.

13. Panel III - Emergency Operations

(a) Each interested government should designate a single centralised organization with a continuing responsibility for co-ordination of disaster assistance activities. Such organizations should be structured to allow maximum use of the technical skills of existing, operating elements elsewhere in the government.

(b) Each interested member government should designate one agency as the recipient of flood assistance requests. In this way, stricken countries could more rapidly make known the nature and location of their needs and the best methods of shipments with regard to border formalities and tax regulations.

(c) It is recommended that interested governments initiate procedures for sending technical or specialised personnel to assist or observe emergency operations in other countries. Such personnel would travel to a flood-stricken country at the request of the host government. Governments interested in receiving technicians and observers at times of disaster should make appropriate stand-by arrangements.

14. Panel IV - Rehabilitation Operations

(a) Flood insurance programs, supported by national governments, should be related to flood plain management and land use control.

(b) Consideration should be given to the study of the disaster legislation of the member nations, and to the maintenance of a file of such legislation at NATO Headquarters. The pilot and co-pilot countries will follow up on this project.

(c) Each interested member government should designate a single agency to assist communities affected by disasters in planning long-range recovery, including reconstruction of industry and housing and new sources of employment. Consideration should be given to projects that facilitate urban and social advancements when planning post-disaster rehabilitation.

15. Panel V - Rôles of Governments, Universities, Industry and Voluntary Organizations

(a) That governments make all possible efforts to achieve better co-ordination between central and regional/local agencies to improve warning systems.

(b) That member governments encourage universities to increase the number and the educational level of students in applied environmental sciences and to include consideration of floods and other disasters in university courses.

(c) That governments improve their capability for early disaster reconnaisance and damage assessment in order to respond more effectively to disaster situations.

CCMS FLOOD MITIGATION MEETING
19TH-23RD OCTOBER, 1970 - VENICE, ITALY

List of Participants

BELGIUM:

Mr. Pianet (Chief of Delegation)	Ministère de l'intérieur, Directeur de la protection civile
Mr. Armand Pien	Institut Royal de Meteorologie
Mr. Linard de Guertechin	Ministère des Affaires économiques
Mr. H. Vandervelden	Ministère des travaux public
Mr. Marcel Stevigny	Ministère des travaux public, Service de la reconstruction

CANADA:

Dr. L.C.N. Burgess	Department of Energy, Mines and Resources
Mr. S.H. Ujjainwalla	Department of Energy, Mines and Resources
Mr. Albert Bentley	Manitoba Provincial Government

FRANCE:

Mr. R. Pervychine	Service hydrologique, Ministère de l'equipement
Mr. Arenou	Ministère de l'interieur

GERMANY:

Dr. Rolf Schaefer (Chief of Delegation)	Ministry of the Interior
Mr. Werner Obenhaus	Ministry of the Interior
Dr. Erich Stange	Ministry of the Interior, Northrhine Westphalia
Mr. Heinz Aschenberg	Hamburg City Government
Mr. Manfred Wegener	Provincial Government, Oberfranken (Bavaria)

Mr. J. Kramer	Office for Water Conservation, Aurich, Lower Saxony
Dr. Liebscher	Federal Institute of Hydrology
GREECE:	
Mr. Constantine Vassis	Consul de Grèce à Venis
ITALY:	
The Honorable Carlo Scarascia Mugnozza (Chief of Delegation)	Senator
Prefetto G. Migliore (Co-Chairman of Conference)	General Director for Civil Protection Interior Ministry
Dr. Roberto Frassetto	National Research Committee, Director, Laboratory for the Study of the Dynamics of Large Masses, Venice
Ing. Tommaso Pirozzi	Section Chief, High Council for Public Works, Ministry of Public Works
Ing. Luigi Lancetti	Chief, Water Department Venice Ministry of Public Works
Dr. Guido Ortolani	Director, Ministry of Public Works
Ing. Livio Dorigo	Inspector General, Ministry of Public Works
Dr. Giuseppe Colucci	Section Chief, Ministry of Public Works
Ing. Giuseppe Mulas	High Council for Public Works
Ing. Giuseppe Batini	High Council for Public Works
Vice Prefetto Vincenzo Aurigemma	Interior Ministry
Prof. Stefano Guazzone	C.N.R
Ing. Giuseppe Oriani	Interior Ministry
Ing. Fabio Rosati	Interior Ministry
Ing. Mario Delle Chiaie	Interior Ministry
Dr. Aldo De Filippo	Interior Ministry

Gen. C.A. Alberto Bongiovanni	Defense Ministry, Chief, Civil Defense Study Center
Dr. Caputo	Interior Ministry
Col. Pasquale Peru	Defense Ministry
Lt.Col. Bruno Mei	Defense Ministry
Dr. Prof. Vitantonio Pizzigallo	General Director of Mountain and Forest Resources, Ministry of Agriculture
Dr. Guiseppe Sartori	Agriculture Ministry
Prof. Ezio Rosini	Agriculture Ministry
Dr. Giovanni Manera	Agriculture Ministry
Dr. Silvano Salvatici	Agriculture Ministry
Dr. Curzio Caneva	Agriculture Ministry
Prof. Giorgio Fea	National Research Committee, Air Force Meteorological Service
Dr. S. Palmieri	National Research Committee, Air Force Meteorological Service
Dr. A. Gazzola	National Research Committee, Air Force Meteorological Service
Dr. B. Bizzarri	National Research Committee, Air Force Meteorological Service
Dr. C. Finizio	National Research Committee, Air Force Meteorological Service
Dr. A. Cicala	National Research Committee, Air Force Meteorological Service
Dr. M. Colacino	National Research Committee, Air Force Meteorological Service
Dr. F. Livona	National Research Committee, Air Force Meteorological Service
Dr. A. Magrini	Interior Ministry
Counselor Emilio Destefanis	Ministry of Foreign Affairs
Miss Renata Archini	Second Secretary, Ministry of Foreign Affairs

Mr. Mario Valiante	Center for Study and Documentation of International Co-operation in the Defense of the Environment
Mr. Luigi Giarrusso	Center for Study and Documentation of International Co-operation in the Defense of the Environment
Dr. Umberto Vignati	Center for Study and Documentation of International Co-operation in the Defense of the Environment
Dr. Alfredo Mingione	Center for Study and Documentation of International Co-operation in the Defense of the Environment
Prof. Aldo P. Amati	Center for Study and Documentation of International Co-operation in the Defense of the Environment
Dr. P. Scala	Center for Study and Documentation of International Co-operation in the Defense of the Environment
NETHERLANDS:	
Mr. P.J. Wemelsfelder	Chief Engineer, Directorate of Water Management and Water Movement, Ministry of Transport
NORWAY:	
Mr. Arne Tollan	State Hydrologist, Norwegian National Committee for the IHD, Secretariat
PORTUGAL:	
Mr. Fausto Teixeira Direito	Ministry of Public Works, Design Department of Hydraulic Services
TURKEY:	
Mr. A. Turhan	State Water Works Directorate, Operations and Maintenance Department

UNITED KINGDOM:

Mr. G. Cole	Ministry of Agriculture, Fisheries and Food

UNITED STATES:

Dr. Daniel P. Moynihan	Counselor to the President
Dr. Hubert Heffner	Deputy Director, Office of Science and Technology
Mr. Darrell Trent	Deputy Director, Office of Emergency Preparedness (OEP)
Mr. Harry Blaney	White House Staff
Mr. Alan Berlind	State Department
Mr. Albert Toner	Deputy Director's Office, OEP
Mr. George M. Grace (Co-Chairman of Conference)	Director, Field Operations Office, OEP
Mr. Donald G. Eddy	Regional Director, OEP Region 6 Denver, Colorado
Mr. Francis X. Tobin	Chief, Field Services Division, Field Operations Office, OEP
Mr. Thomas R. Casey	Chief, Operational Analysis Division, Field Operations Office, OEP
Mr. Eugene Klebenov	Planning Review, OEP
Mr. Philip McIntire	Field Operations Office, OEP
Mr. John J. Policastro	CCMS Project Officer, OEP NATO Brussels
Mr. B.J. Tofani	Chief, Policy and Analysis Division Civil Works Directorate, Corps of Engineers
Mr. Joseph M. Caldwell	Technical Director, Coastal Engineering Research Center, Corps of Engineers
Mr. George Phippen	Chief, Flood Plain Management Service Directorate of Civil Works, Corps of Engineers

Mr. Marshall M. Richards	Chief, Hydraulic Services Division, Office of Hydrology, ESSA Weather Bureau
Mr. George Bernstein	Federal Insurance Administrator Department of Housing and Urban Development
Dr. Oswald Ganley	Scientific Attache, American Embassy, Rome
Mr. F. Catanoso	USIS, Milan
Mr. P. Garau	USIS, Rome
Mr. B. Orlando	USIS, Trieste
Miss Barbara McKenna	Executive Secretary to US Delegation
Mrs. Elke Abitol	CCMS Project Office Secretary

NATO International Staff:

Prof. Gunnar Randers	Assistant Secretary General for Scientific Affairs, Chairman of the Committee on the Challenges of Modern Society
Mr. Loic Thiebault	Secretary of the Committee on the Challenges of Modern Society
Mr. Marino Deveglia	Civil Emergency Planning Directorate

OBSERVERS:

Mr. Enzo Pironio	CE (Commission of the European Communities) Social Affairs Section
Mr. Ludolf von Kotze	CE (Commission of the European Communities) Development Aid
Ambassador G. Talamo Atenolfi	President, International Relief Union
Ambassador Schwarzenberg	Sovereign Order of Malta

CONTENTS

BELGIUM

1. Organization of Government Relief Agencies in cases of disaster
(R. Pianet)

2. Funding of relief for victims of floods
(R. Pianet)

3. Co-ordination of relief in general. Emergency action committees (Co-ordination Committees). Pre-established planning.
(R. Pianet)

4. Methodes de Prevision
(Pien)

5. Amenagement de Bassins Fluviaux
(Pien/Vandervelden)

6. Mesures de Prevention et d'Alerte
(Pien/Vandervelden)

7. Mesures d'Urgence en Periode d'Alerte ou en Periode d'Inondations Provoquees par une Maree-Tempete
(Pien/Vandervelden)

8. Organisation de l'Aide Medicale Urgente
(Dr. Beckers)

CANADA

9. The Red River Floodway and Related Flood Control Works
(Weber)

10. An Integrated System of Flood Forecasting and River Control in the Province of Ontario, Canada
(McMullen)

11. Ice and River Control
(Bryce)

12. Program Guide to agreement covering a plan for flood control in the Lower Fraser Valley, British Columbia

13. A Preliminary Report on Flood Damage Reduction
(Burton)

CANADA (Contd)

14. Airphoto Interpretation as an Aid in Flood Susceptibility Determination
(Burgess)
- attached: Remarks by Dr. Burgess to Hazard Reduction Panel on same subject

15. Flood Plain and Conservation Lands
(A Statement of Policy)

16. Conservation Authorities in Southern Ontario
(Barnes)

17. Guidelines for Peacetime Disaster Costs Eligible for Financial Assistance

18. Rôles of Governments, Universities, Industry and Voluntary Organizations
- attached: Manitoba Flood Information

19. Report on Flood Control in Canada
(Weber)

GERMANY

20. High Water Reporting Along Federal Waterways

21. Floods Caused by unusually heavy rainfalls in Areas not normally exposed to such dangers

22. Organization and implementation of disaster control in the Federal Republic of Germany

23. Report on German relief operations in disaster abroad

ITALY

24. The Prediction of sea tides at Venice
(Palmieri/Finizio)

25. A numerical model of the Adriatic Sea for the study and prediction of sea tides at Venice
(Finizio/Palmieri/Riccucci)

26. Metodo Obiettivo di Preallarme per Precipitazioni Intense et Estese su Regioni del Territorio Nazionale
(Palmieri/Finizio)
(Optimal Decision Rule in Severe Storm Warnings)

ITALY (Contd)

27. A model of detailed analysis - The meteorological conditions over Italy during 31st August-4th September, 1965 (Visconti/Capelli/Fagioli)

28. Primi Risultati di una Indagine sulla Distribuzione delle Precipitazioni in Italia in Relazioni alla Situazione Meteorologica (Gazzola) (Predictions and Meteorological Fields)

29. Proposta per un Sistema Operativo di Satelliti Italiani per la Meteorologia del Mediterraneo (Bizzarri, Colacino, Fea, Giorgi) (An Operational System of Meteorological Satellites for the Area of the Mediterranean)

30. Lineamenti di un Progetto per il Centro Nazionale di Acquisizione ed Elaborazione dei Dati da Satellite (Bizzarri, Fea, Giorgi, Palmieri) (Design of National Centre for the Collection and Elaboration of Satellite Data)

31. PREMETEO, NRC Project for the Development of Meteorology in Italy (Giorgi, Fea)

32. Histoire et Types d'Alluvions en Italie pour la Periode 1951-1968

33. Methods for the Prediction of Storm Surges (Dr. Frassetto)

34. Phenomenology of Floods in Venice as produced by storm surges over the Adriatic (Tomasin)

35. Propagation of flood wave in rivers with specific reference to the Arno River (F. Greco/Pisa University)

36. Sicurezza Sociale e Protezione Civile (Interior Ministry)
La Protezione Civile in Italia (Interior Ministry)

ITALY (Contd)

37. Intervento del Direttor Generale Dr. Prof. Vitantonio Pizzigallo sulle Misure Permanenti per Ridurre i Pericoli Ricorrenti delle Alluvioni con Paricolare Riguardo all' Attivita di Prevenzione Affidata all'Administrazioni Forestale nel Settore della Difesa e Conservazione del Suolo (Ministry of Agriculture, Forest and Mountain Resources)

38. Interventions of the Italian Armed Forces for the assistance of populations in distress

NETHERLANDS

39. Fighting Flood and storm surges in the Netherlands

UNITED KINGDOM

40. Land drainage and flood protection in England and Wales

41. London and East Coast tidal flood warning system (Cole)

42. Flood plain planning and frequency studies (Cole)

UNITED STATES

43. A Uniform technique for determining flood flow frequencies (Water Resources Council)

44. Proposed flood hazard evaluation guidelines for Federal Executive Agencies (Water Resources Council)

45. Introduction to flood proofing (Shafer)

46. Making flood warnings more timely (Richards)

47. Elements of river forecasting (ESSA)

48. Operation foresight: A valuable precedent (Tarbox)

UNITED STATES (Contd)

49. OEP Emergency flood fighting operations (Eddy)

50. OEP Model field organizations to respond to natural disasters

51. Individual assistance program (Case Study - Lubbock Texas)

52. The National Flood Insurance Program (Bernstein)

53. Disaster assistance for long-range economic recovery
(Bourgin)

54. Federal disaster relief assistance - A historical review (OEP)

55. Federal disaster assistance handbook for Government officials (OEP)

ORGANIZATION OF GOVERNMENT RELIEF AGENCIES IN CASES OF DISASTER

R. Pianet (Belgium)

1. The Civilian Protection Law of 31st December, 1963 provides that this protection - formerly conceived for organizing the survival of the nation in wartime - will include the mission of contending with disasters of all kinds and at all times, hence also in peacetime.

2. The law authorizes:

- recommending a civilian protection programme to the public authorities as well as to private agencies and citizens individually;
- requisitioning of persons and property;
- ordering or prohibiting civilian population movements;
- co-ordinating the preparation and execution of protective measures in departments other than that of the Interior;
- organizing means for protection.

3. The appearance of peacetime obligations has perhaps induced restraint in the organization of measures proper to Civilian Protection but has permitted stress to be laid on the co-ordination mission.

The latter is very profitable and relatively not very costly in peacetime.

It has already been applied with success in the mitigation of floods, among other cases.

4. The forces for the Belgian Civilian Protection presently include:

- a national command centre, staffed with civilian protection officials in civilian status, employed full-time and assigned - except in periods of disaster - management, logistic and command tasks for routine interventions;
- nine provincial centres, staffed with civilian protection officials as above but reinforced, in cases of disaster, by volunteers (trained for command and liaison duties, or for rescue work, or for NBC protection);

- fifty regional centres, dependent on and distributed among the nine provincial centres; these are staffed solely with volunteers assigned to emergency echelons, to primary and secondary reserves (see item 5 below);

- two hundred intervention centres for rescue work, grouping 10,000 trained volunteers assigned to each of the fifty regional centres in proportion to the size of the population;

- one hundred and fifty NBC detection posts, composed of 1,200 volunteers, connected to the regional and provincial centres for the transmission of ALL information in cases of disaster, even other than NBC, and for reporting specific NBC perils;

- four mobile columns, consisting of permanent personnel equipped with heavy specialized material allowing them to deal with a great number of disasters (fires, pollution of inland waters through hydrocarbons, collapses(1), floods, etc.).

5. The creation of emergency echelons and of primary and secondary reserves among volunteers is based on the following criteria:

- Emergency Echelon: volunteers who, with the consent of their employers or, in the case of independent workers, by personal contract, are on call at all times within less than one hour;

- Primary Reserves: volunteers able to join up for relief work at three hours' notice;

- Secondary Reserves: volunteers available in the evening, on weekends, or after a period corresponding to their normal working hours in civilian life.

6. The national command centre and the provincial centres participate actively in a co-ordination action (new) based on a Royal Decree dated 16th September, 1966, passed in implementation of the Civilian Protection Law of 31st December, 1963, and which grants a co-ordination right (that is to say a temporary command) over all public and private agencies, capable of affording relief in cases of disaster, to:

- the Minister of the Interior, if more than one province is involved;

- the Governor of a Province, for an action which requires only the intervention of the forces in his province.

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(1) collapses of construction, caves-in, landslides, etc.

This temporary command involves:

- maintenance of the responsibilities and statuatory rights of each agency called upon, including the financing of actions undertaken;

- the right to call for the intervention of any public or private agency which, by reason of its statutes, the capabilities of its personnel or the specialization of its material, is able to bring reasonable relief;

- the respect of legal or actual priorities (for example, rapidity of the intervention through services on call night and day, distances to be covered, legal obligations, etc.).

NOTE: Consequently, Network 900 (sole call network for aid to the injured on roads) and the local and regional fire brigades remain the units for initial intervention, save in catastrophes which, by reason of their immediately discernible magnitude, or of their specific symptoms, or of an already established relief plan, have justified a direct appeal to the Governor of the Province.

7. The co-ordination action is sub-divided into three phases:

- short-term prevention;

- action;

- reconditioning.

NOTE: Prevention referred to here envisages only post-accident action and is described as "short-term" in order to differentiate it from prevention (long-term) directed at avoiding accidents.

8. Short-term forecasting is progressively taking a concrete form in Belgium through:

- establishment of co-ordinating offices in each province, directed by the Civilian Protection authority and which, in anticipation of possible specific or chronic accidents, draw up a permanent inventory of the resources existing either within the traditional relief agencies or outside of these;

- selection of the location and composition of joint temporary command posts, to be set up in cases of disaster;

- drawing up OSR (Rapid Relief Organization) plans defining:

  (a) the scope of the plan (type of accident anticipated: flooding in a particular basin; pollution by hydrocarbons of ports, beaches, watery terrain; nuclear pollution, etc.);

  (b) the outset alarm, the alarm message as well as its drafter and addressees;

  (c) immediate, secondary and co-ordinated action.

9. The action planned consists of:

- bringing into play automatically the traditional relief agencies (fire brigades in most cases, coastal Life Guards, mine rescue workers, Network 900 for bringing aid to the injured on roads);

- as a complement, bringing the Civilian Protection forces into play;

- assistance from the Department of the Interior's Intervention Fund, intended for financing work ordered by the Civilian Protection Authority from public or private agencies not normally endowed with funds for relief tasks;

- subsequently, bringing into play the Emergency Relief Fund (or Disaster Fund) intended for financing, without security or as advances, material emergency aid to endangered persons (food supplies, housing, etc.).

10. Reconditioning - inasfar as Civilian Protection is concerned - is still only a project.

Assimilation of damage caused by natural disaster to that caused by war is envisaged. (See special communication on this subject.)

FUNDING OF RELIEF FOR VICTIMS OF FLOODS

R. Pianet (Belgium)

PRESENT SITUATION

1. At present, funding of relief in cases of floods or of any other natural disaster is achieved by means of:

- the Intervention Fund, controlled by the Ministry of the Interior, Civilian Protection Administration;
- special credits granted after the disaster occurs, chargeable to the budget of the Ministry of Agriculture (damage to harvests and livestock) or to that of the Ministry of Economic Affairs (industrial damage) or to that of the Ministry of the Interior (damage to private property and assistance to persons) or to the Communes;
- a replenishment of the Belgian Red Cross Disaster Fund by the Ministry of Public Health;
- donations, spontaneous or solicited by a semi-official association.

2. The Intervention Fund will be studied later on. It is, in effect, a standing fund and will be part of a comprehensive funding system planned by the Belgian Government.

3. Spontaneous or solicited donations are either paid into the Red Cross Disaster Fund or into a temporary relief fund created by a Minister, a Governor, a Burgomaster or by the Belgian Radio and Television System, etc.

In the project already announced, these donations will be paid into one standing fund, the Emergency Relief Fund (see below).

4. The Belgian Red Cross Disaster Fund will have less reason to exist if the project is realized but, in view of the private character of this charitable institution, it is anticipated that the Disaster Fund will continue to exist - but without being replenished by the Ministry of Public Health - on the same basis as mutual aid funds exist in other hospitalization and charitable institutions, etc.

Given the importance and orientation of the Belgian Red Cross activity in peacetime, it is probable that it will have a consultative - but not deliberative - voice in the management of certain funding methods envisaged by the state.

5. A thorough study of the present funding system, begun after the sea dikes burst in 1953 but conducted in more detail after the disastrous inland floods in 1966 and 1967, revealed that the funding described above presented very serious drawbacks, i.e.:

- in the absence of an established objective criterion, the character of a disaster is often attributed to a natural phenomenon only under the pressure of public opinion (number of victims, sentimental aspect of certain situations) or by the effort of victims grouped in professional associations always recognised and heard by the State (agriculture, for example) with the result that total discrimination takes place from the start (to finance or not to finance) between the victims of disasters of different natures;

- funding decided upon after disasters - that is, after the period from the moment the disaster occurs until public opinion and the efforts of pressure groups become effective - does not permit taking any financial action during the most crucial hours - i.e., the very first hours;

- the lack of a common criterion and of preliminary concertation with those authorities capable of opening emergency credits often leads to the creation of several funds for an identical purpose and entails:

    - either mismanagement of certain funds, leaving superfluous money on hand;

    - or the multiplication of aid to the same person;

    - and, in any case, lack of control over the final destination of the public funds thus released;

  (On the other hand, the special credits opened by a commune are often in the form of a cheque drawn on a fund already in deficit but which will finally be honoured by the State by means of "subventions to communes with overburdened finances".)

- the lack of continuity in the funding system compels defining, as each disaster occurs, the distribution criteria (damage evaluation, percentages guaranteed, interest rates on loans, rates for donations without security) all of which creates a new discrimination, this time between victims of two recognized disasters.

(This second discrimination is influenced by the relative soundness of the Treasury as well as by the occasional force of the pressures which have succeeded in having the disaster recognized as a disaster to be financed.)

NEW FUNDING PROJECT AND TERMS OF ITS PRINCIPLES

Introduction

6. In spite of (or by reason of) the long delay intervening between the beginning of the studies and the present day, it may be said that the project described below is very close to being realized.

Indeed, the studies have allowed no more than two or three issues with political incidence to subsist. The operational machinery no longer encounters any fundamental objection.

Since all central administrations concerned have collaborated in this project, it may be reasonably assumed that the political issues will easily be lifted when the first major disaster occurs.

The Project as a Whole

7. If the project is realized, there would be the following:

- The Intervention Fund of the Ministry of the Interior (Civilian Protection Administration), maintained by standing budgetary credits and replenished up to a ceiling of several million Belgian francs, intended for financing:
    - supplementary services of the intervention forces for Civilian Protection;
    - supplies of materials and equipment necessary for a large-scale emergency action, preliminary purchase of which was impossible or inopportune;
    - services of agencies or citizens who, although called up for reinforcement by the Civilian Protection Administration, do not have the financial means for this purpose by reason of their organization or personal status.

- The National Relief Fund, common to the Ministry of the Interior and the Ministry for Public Health, maintained either by public fund credits of various types or by donations; it is intended for financing:
    - immediate material aid to persons (food, clothing, shelter), granted without security;
    - advances of funds, eventually recoverable, for emergency reconditioning of housing and working conditions when a vital emergency prevents waiting for a final evaluation of damages, their relation to the disaster, or their coverage by any compensation system.
- The National Fund for Public Disasters (title not yet official), managed by the Ministry of Public Works and maintained either by public funds or by extra insurance premiums; it is intended for financing repair of damages to buildings in natural disasters, according to a principle similar to that for war damage compensation.
- The National Fund for Agricultural Disasters (title not yet official), similar to the fund mentioned in paragraph above and managed by the Ministry of Agriculture; it is solely for agricultural risks (harvests and livestock).

General Principles

8. As a whole, the project must provide for:

- Standing availability of funds for immediate action.
- Establishment of objective criteria for the distribution of funds.
- Equality of all victims with respect to State assistance.

  (A major problem was that of assistance to foreigners. A second problem was that of aid to isolated victims.)
- Respect of the principle of national solidarity, that is, of the financial contribution by eventual victims as a whole.

- Respect of the finality of credits (donations and advances) through control of their use and penalizing abuses.

- Non-intervention by the State in coverage of insurable risks.

ANALYSIS OF THE INTERVENTION FUND

9. The Intervention Fund can be assimilated, in fact, if not by right, to a standing operational credit. However, its use must, in principle, be limited to financing:

- actions proper to Civilian Protection, the financial incidence of which could not be anticipated when drawing up the annual budget;

- actions directed by the Civilian Protection Administration to juristic or physical persons not normally under its authority by statute or convention and who have no credits available for such actions.

10. Each year, the Fund must be replenished by budgetary credits, taking into account:

- funds withdrawn during the current year;

- existence of deferred contracts (sand bags for bursting dikes, products for contending with pollution of waters and lands by hydrocarbons);

- probability of certain disasters (floods, droughts).

11. Expenditures will be made by the Minister of the Interior until execution orders are published.

Up to the present, it was standing policy for a senior official of the Civilian Protection Administration, who had operations among his attributions, to open credits in emergencies, either after consultation with the Cabinet of the Minister or subject to later justification.

12. Certain difficulties still exist in operating the Intervention Fund. These are due to very dissimilar factors, some of which are enumerated below:

- the co-ordination rôle of the Civilian Protection Administration is of recent creation and is still not very well understood by certain external authorities or agencies called in for collaboration; consequently, very often certain expenditures are erroneously considered as chargeable to the State when they are inherent to these organizations' own functions (this is particularly true of the communes);

- the Civilian Protection Administration itself might perhaps be tempted to charge to this fund expenditures which clearly must be anticipated but are not authorized by the Government in periods of austerity;

- certain agencies, even State agencies, have a tendency to intentionally burden their own operational budget by charges made to this fund, either by dispensing with the principle of intervention in case of disaster (in spite of the obviousness of their civic duty) or by enacting rules aiming at having their intervention financed by third parties (among which the Civilian Protection Administration), rules which are hardly compatible with a sound view of the missions of the State and of the nation as a whole.

13. As a general rule, and in spite of the restrictions mentioned in paragraph 12, the existence of the Civilian Protection Administration's Intervention Fund has permitted many operations for the rescue of persons and property, unconceivable in the past.

ANALYSIS OF (THE PROJECT FOR) THE NATIONAL RELIEF FUND

14. Organization of population survival in cases of disaster is the responsibility of the Ministry of the Interior, but the Ministry of Public Health's attributions include supervision or management of sanitary care, public hygiene and social medicine in normal times as well as in emergencies.

This is the reason why a special convention governs the relations between these two departments for cases in which a generalized disaster requires, in addition to rescue and clearing away operations, the application of mass medicine for the benefit of the injured or victims.

This same Ministry of Public Health exercises, in addition, a certain supervision over public utility agencies dealing with hospital care, sanitary care or prevention.

15. Therefore, it has appeared indispensable to conceive in common the creation of the National Relief Fund for the relief of persons stricken in their way of life by disasters.

16. The National Relief Fund (in project form) will have as its purpose:

- feeding and housing, at State expense, of all victims of a natural disaster when the magnitude, suddenness, place and moment of the catastrophe prevents a systematic setting into motion of administrative wheels for the application of rigid or objective criteria;

(Even in the case of a disaster caused by man, this Fund could intervene, but such a case is not the object of this Colloquium.)

- in these same cases, to restore articles indispensable to the immediate reoccupation of homes and to the pursuit of professional occupations (for example, craftmanships, family care), withholding of which would create suffering on the one hand and on the other an increased burden on the State.

17. Any victim can benefit by the Relief Fund, without distinction of nationality or domicile.

18. Distribution of food and bedding alone will be made without security.

All other financial aid will be considered as advances to be deducted from the final compensations paid either by insurance companies or from the Disaster Fund (see below). These advances will, however, be made to victims having no claim on compensation.

19. The National Emergency Fund will be managed by a committee of four senior officials (one for each department), chaired by the Minister of the Interior or by the Director General of the Civilian Protection Administration.

In an emergency, the senior official of the Civilian Protection Administration responsible for operations, or the Governor of the Province, may decide in lieu of the Committee whether the fund is to intervene and must inform the Committee of their decision within 48 hours.

20. Actual distribution is done by a Provincial Relief Committee, chaired by the Governor and composed of three members (representing the Provincial Government, the Civilian Protection Administration and the Public Health Department).

This Provincial Committee may call for assistance from representatives of local authorities and of relief agencies, but these will only have a voice as consultants.

21. The National Relief Fund will be maintained by State remittances (from the Disaster Fund, among others) and by remittances from the provinces, the communes, public utility organizations and from private persons and agencies.

(Note: The paragraphs hereafter summarize a more detailed explanation given in the corresponding French version.)

ANALYSIS OF THE FUND FOR PUBLIC DISASTERS (IN PROJECT FORM)

22. The Fund for Public Disasters will operate exactly as does the War Damages Fund and, like it, be managed by the Department of Public Works.

It will have standing committees, thus avoiding having to create them at the moment of each disaster. However, the members will not be appointed for an exclusive mission but are, for instance, magistrates, officials of the Reconstruction Administration or Provincial Government officials.

The law creating this Fund will establish the following:

- evaluation criteria for damages;
- criteria for allocation of funds;
- procedures for introducing briefs, decisions, appeals;
- methods of transferring rights in case of death, sale of damaged property;
- penalties in cases of fraud.

Since the entire machinery is only a readaptation of rules already applied in settling the 1940-45 and Congo damage claims and since it will be supervised by the Reconstruction Administration especially set up for such work, application of this law will be very easy.

23. The creation of this Fund is based on the notion that the State would play for its citizens the rôle of an insurance agent for certain risks not normally insurable.

In order to avoid an excessive burden on the Treasury, precise definitions are given for:

- risks;
- property thus guaranteed;
- beneficiaries;
- extent of the guarantee;
- mode of compensation;
- maintenance of the Fund.

Risks

24. The Fund will intervene only in cases of natural disaster. Hence all catastrophes caused by man will be excluded; in this case, it is almost always possible to establish responsibilities and the National Relief Fund will be able to grant recoverable advances. However, it has not been possible to define a natural disaster. Therefore, the Government will be called upon, in each case, to decide whether the Fund for Disasters should intervene or not.

The drawbacks inherent to such a decision (see paragraph 5) will nevertheless be slighter than in the present situation because:

- immediate needs are covered by the National Disaster Fund;
- the entire administrative machinery will have been set up.

Property

25. Only damages to real estate, non-sumptuous personal property and to working implements which normally can be insured against certain normal risks (fire, for instance) will be considered.

Ships, boats, etc. will be excluded as these are insured against all risks, including those stemming from natural disasters.

Beneficiaries

26. Proprietors (or lessees in the lease/finance or leasing system) who are Belgian nationals or citizens of a country granting identical rights to Belgians residing therein may benefit from the Fund for Disasters.

Victims not of Belgian nationality or who do not benefit by the reciprocity regulation are thus excluded from final compensation. However, it was stated above that they were entitled, as any other victim, to receive aid from the National Relief Fund (emergency revictualling and advances for subsistence).

Extent of the Guarantee

27. The State will intervene only for compensation of property actually covered by an insurance policy against normal fire risks and in proportion to the value insured.

The rare cases of non-insured paupers will be taken care of by the Relief Fund.

Mode of Compensation

28. Compensation may include indemnities for repairs and grants of complementary credits for restoration at reduced rates of interest which the State guarantees and pays the remaining interest and expenses.

A franchise will be deducted.

On the other hand, expenses for temporary work done in view of limiting the damages, as well as expert appraisal costs, will be taken into account.

If reinvestment in the damaged property is waived, or property acquired in replacement, the State's financial intervention will be limited to the amount of the damage evaluated on the basis of the market value of the damaged property, the transfer of ownership fees allowed for expropriation at State expense being added to this amount.

Maintenance of the Fund for Disasters

29. Three methods for maintaining the Fund were initially envisaged:

- standing collection by the State of a percentage of all fire insurance premiums;

  Drawbacks were:

  (a) useless inflation of the Fund in the absence of disasters;

  (b) positive increase if the insurance premiums and pressure exercised by insurance companies on their customers for increasing the amount insured.

- increase of that portion of the property tax reverting to the State;

  Drawbacks:

  (a) as under (a) above;

  (b) owners of personal property do not participate in the effort.

- opening a budgetary credit at the time of the disaster.

  Drawback:

  continuing discrimination between successive disasters.

30. The system recommended at present consists of:

- setting the Fund for Disasters in operation on the day the first disaster occurs (this prevents prior inflation of the Fund);
- immediate funding by a Treasury advance;
- continued funding by collecting increases in insurance premiums as of 1st January of the following year.

NATIONAL FUND FOR AGRICULTURAL DISASTERS (PROJECT FOR)

31. The principles for operating this fund for Agricultural Disasters are identical to those for the Fund for Public Disasters.

32. The two funds have been separated because:

- the experts evaluating the damages and the officials handling the case files belong to another department, the Department of Agriculture;
- epidemics and epizooties can cause serious, non-insurable damages without there having been a natural disaster in the usual sense of the term;
- fire insurance cannot serve as a basis on which to calculate damages nor as a mode for funding.

CONCLUSION

33. The Intervention Fund of the Civilian Protection Administration is already facilitating the breaking in of a system of rescue methods in cases of disaster.

34. The Civilian Protection Administrations's committees, at national level and in the provinces are already calling the attention of all public agencies and relief organizations to the need and feasibility of concentrating into the hands of the Governor of the Province all relief funds appearing spontaneously in cases of disaster.

35. The legal and statuatory texts for creating the National Relief Fund and the two funds for disasters are practically complete.

36. As soon as these are published, it will be possible to have standing funds available for immediate relief work and reconstruction on the basis of objective criteria.

CO-ORDINATION OF RELIEF IN GENERAL, EMERGENCY ACTION COMMITTEES (CO-ORDINATION COMMITTEES), PRE-ESTABLISHED PLANNING

by R. Pianet (Belgium)

CO-ORDINATION OF RELIEF IN GENERAL

Rule:

1. Article 4 of the Civilian Protection Law of 31st December, 1963 vests authority in the Minister of the Interior for the co-ordination of:

- the preparation,
- the execution,

of the measures intended for ensuring the protection of civilian populations in cases of disaster.

Restriction:

2. The Minister of the Interior may not, therefore, decree arbitrarily measures for which other Ministers are normally competent, nor may he decide to co-ordinate ex officio already existing texts by applying modifications to them.

Examples:

- Protection of workers and of the population in general against radiation ionization (Minister of Public Health);
- Security measures during construction of oil and gas pipelines, compressed air ducts, etc. (Ministry of Public Works);
- Security measures (fire or other risks) during construction of buildings (Minister of Public Works);
- etc.

3. Co-ordination in the Preparation of Measures

Fire Prevention:

Preparation of fire prevention measures is institutionalized by the creation of an Interministerial Board for Fire Prevention, which examines all draft regulations for fire prevention.

The Board is chaired by the Director General of the Civilian Protection Administration.

Other Fields:

- Preparation of other protection measures has not yet become institutionalized or generalized.
- This preparation progressed after each disaster and has materialized through direct contact between officials of the various departments.
- It generally becomes concrete through the insertion of identical security stipulations decreed by the various departments.
- These stipulations relate to:
    - the requirement for providing an alarm system connected to the "consolidated call for rescue system", known as Network 900;
    - the requirement for keeping Civilian Protection informed on access plans, alarm system, special risks for an establishment threatened;
    - the compulsory call upon Civilian Protection for reinforcements in major disasters.
- The most complete achievements to date concern protection against radiation ionization and of the operation of pipelines.

4. Co-ordination in the Execution of the Measures

Fire Fighting:

A Royal Decree dated 8th November, 1968, implementing the Civilian Protection Law, requires the Firemen's Corps to group in homogenous regions and to respect, among themselves, a triple echelon hierarchy, which permits automatic cognizance of first aid operations, reinforcement and relieving personnel. It permits calling upon Civilian Protection for reinforcement; it requires calling the latter in in case of fire in an establishment under special surveillance.

Other Disasters (including floods):

A Royal Decree dated 19th September, 1966, issued in implementation of this same Civilian Protection Law, entrusts the Governor of the Province (or the Minister if more than one province is concerned) with the co-ordination of the intervention in cases of calamity, catastrophes or disaster requiring calling upon the resources of several agencies. (See, in this respect, "Belgian Contribution on the Organization of Government Agencies".)

EMERGENCY ACTION COMMITTEES (In Belgium, Boards and Committees for Co-ordination of Relief)

5. Upon the first applications of the Royal Decree of 19th September, 1966, in co-ordinating intervention in cases of disaster, it appeared that the united operational command, created for the duration of the disaster, was encountering serious difficulties unless prepared in advance.

6. Effectively: the specialization of the various forms of relief is not always clearly defined:

- all the actual resources for relief are not always known, especially in the private sector;
- hesitations sometimes arise in the temporary hierarchy (collaboration or subordination);
- at times, a disproportion exists in the number of rescue workers rushing into action during the initial hours of the disaster and the number required to relieve these, or a lack of equilibrium arises in the geographical distribution of relief actions, due to a sentimental attachment of the personnel to their own territory or to assignment thereto.

7. The Governors who designate the provincial director of Civilian Protection as Technical Co-ordinator have thus convened under their chairmanship all departmental heads of the agencies and organizations in their province for the purpose of studying:

- resources for relief (manpower, material and funds) available to each, either directly or by letting contracts to the private sector;
- means of communication during and outside of working hours (or existence of round the clock standby duty);
- chronic risks and sensitive spots in the province.

8. It was revealed quite rapidly that the assembling of heads of different departments had proved most fruitful and was, in fact, desired by all concerned.

9. On the other hand, it was also revealed that all departments were not affected by all interventions in cases of disaster (specific or geographically limited disasters) and that not all of them were qualified or required to intervene at the initial stage (lack of standby service, specialization in reconditioning work, etc.).

Therefore, one (or more) restricted board(s) for co-ordinated action was (were) created.

These boards always consist of:

- one representative from the Fire Brigades;
- one representative from a sanitary department;
- one representative from the Gendarmerie and/or the Army;
- one representative from Civilian Protection.

When the boards are set up for a determined region (for example, a river basin particularly threatened by floods) they include in addition:

- the regional delegate concerned;
- the Burgomasters.

These boards convene automatically at the first alarm affecting them, except for the Burgomasters, who proceed to their town hall but remain in liaison with the board.

10. Co-ordinated action boards have already functioned, for instance during floods:

- centralization of information and of calls for aid;
- hence, more speedy response, better distribution of the resources available and better chances for discovering complementary resources.

11. The joint use of resources for an action conducted jointly had, as an unexpected but very satisfying result, that of stressing very strongly the responsibilities of the local authorities themselves and previous contingency needs.

The outcome was that stocks of sandbags, which in the past were almost theoretical, actually came to be deposited and replenished periodically in threatened communes, the list of building contractors kept up-to-date and sand and gravel pits came to be better known to the authorities.

12. Another appreciable result: disappearance of panic among the inhabitants as well as among the local authorities who feel the constant "presence" of possible mutual aid.

PRE-ESTABLISHED PLANNING (O.S.R. Plans)

13. The constant success of co-ordinated actions already initiated, on the one hand, and on the other the lack of generalization for the system, have incited the Department of the Interior to conceive a compulsory system of pre-established planning under the designation O.S.R. (Organization for Speedy Relief (Rescue), comparable in part to France's ORSEC plans (OR SEC - Organization for Relief).

14. A ministerial circular dealing with this subject is in preparation (July 1970).

15. After publication of this circular, there will be the following plans:

- a general O.S.R. Plan, formulating the principles for all the special O.S.R. plans and notably, for the authority of the Governor acting on the basis of the Civilian Protection Law, and for the requirement of organizing an alarm system, etc.;
- a series of O.S.R. plans corresponding to specific risks due either to the chronic re-appearance of certain natural disasters or to the presence of industries or other community property which, in case of accident, calls for a special action to rescue persons or to safeguard an element of the general economy.

16. The following O.S.R. plans already exist:

- OSR Mol (site of the Centre for Nuclear Studies);
- OSR Chooz (site of the nuclear production reactor located in France on the Belgian frontier); (joint project with France).

17. The Department of Public Works had ~~nevertheless~~ conceived, prior to the creation of Civilian Protection, a co-ordinated alarm plan. It relates precisely to the floods caused by storms at sea.

This plan concerns the coast and the lower reaches of the Escaut River.

METHODES DE PREVISIONS

M. Pien (Belgique)

A. A courte échéance

(1) Méthode classique - carte du temps (surface et altitude)

- documents fac-similés
- ballons sondes (2 radiosondes et 4 sondages vent)
- documents sondages
- durée (plotting + analyse) ± 4 h
- futur immédiat : plotteur électronique.

(2) Satellites météorologiques - opérationnels à Uccle depuis janvier 1968 grâce à une station APT (Automatic Picture Transmission).

Satellites suivis - (actuellement) :

(a) Orbites polaires : 3 passages par jour à Uccle :

ESSA 8 (lancé le 15 décembre 1968 - USA)

NIMBUS 3 (lancé le 14 avril 1969 - USA)
(+ photos en infrarouge)

ITOS 1 (lancé le 23 janvier 1970 - USA)
(+ photos en infrarouge)

(b) Orbite géostationnaire - au-dessus de l'embouchure de l'Amazone :

Captation continue à Uccle ATS 3 (lancé le 5 novembre 1967 - USA), indispensable pour les USA afin de suivre les cyclones tropicaux et les tornades. L'Europe possède ainsi une photo de l'Atlantique occidental.

Avantages : Photos au moment même. Les cartes du temps de surface sont immédiatement corrigées, surtout sur l'Atlantique où le nombre des observations météorologiques est petit.

Grâce à ces photos de nuages on voit si l'activité d'une perturbation (qui se déplace vers l'Europe) est grande ou pas et si les cyclones prennent un caractère de tempête.

T.V. : Photos de nuages (+ contours européens) montrées durant le bulletin du temps.

Durée de la prévision : ± 24 h.

(voir photo nuage).

B. A moyenne échéance

Prévision numérique quotidienne opérationnelle à Uccle depuis novembre 1961 grâce à l'ordinateur électronique IBM 7070 remplacé en août 1964 par l'IBM 7040 et remplacé de nouveau en septembre 1968 par l'IBM 360-44.

Modèle d'atmosphère étudié par le Dr. J. Van Isacker qui permet de prévoir les paramètres suivants : l'altitude de la surface de 500 mb et l'épaisseur comprise entre les surfaces de 300 et 700 mb.

Les prévisions se font pour l'hémisphère nord.

L'équipement électronique comprend un traceur de courbes ce qui permet d'obtenir les cartes d'altitude dessinées c'est-à-dire des cartes directement utilisables au bureau du temps.

Durée de l'opération : 2 h 30 min.

Durée de la prévision : 48 h et 72 h à l'étude.

Radio, TV et téléphone automatique : transmettent chaque jour les prévisions pour les 3 jours à venir.

(Voir carte d'altitude calculée par l'ordinateur électronique).

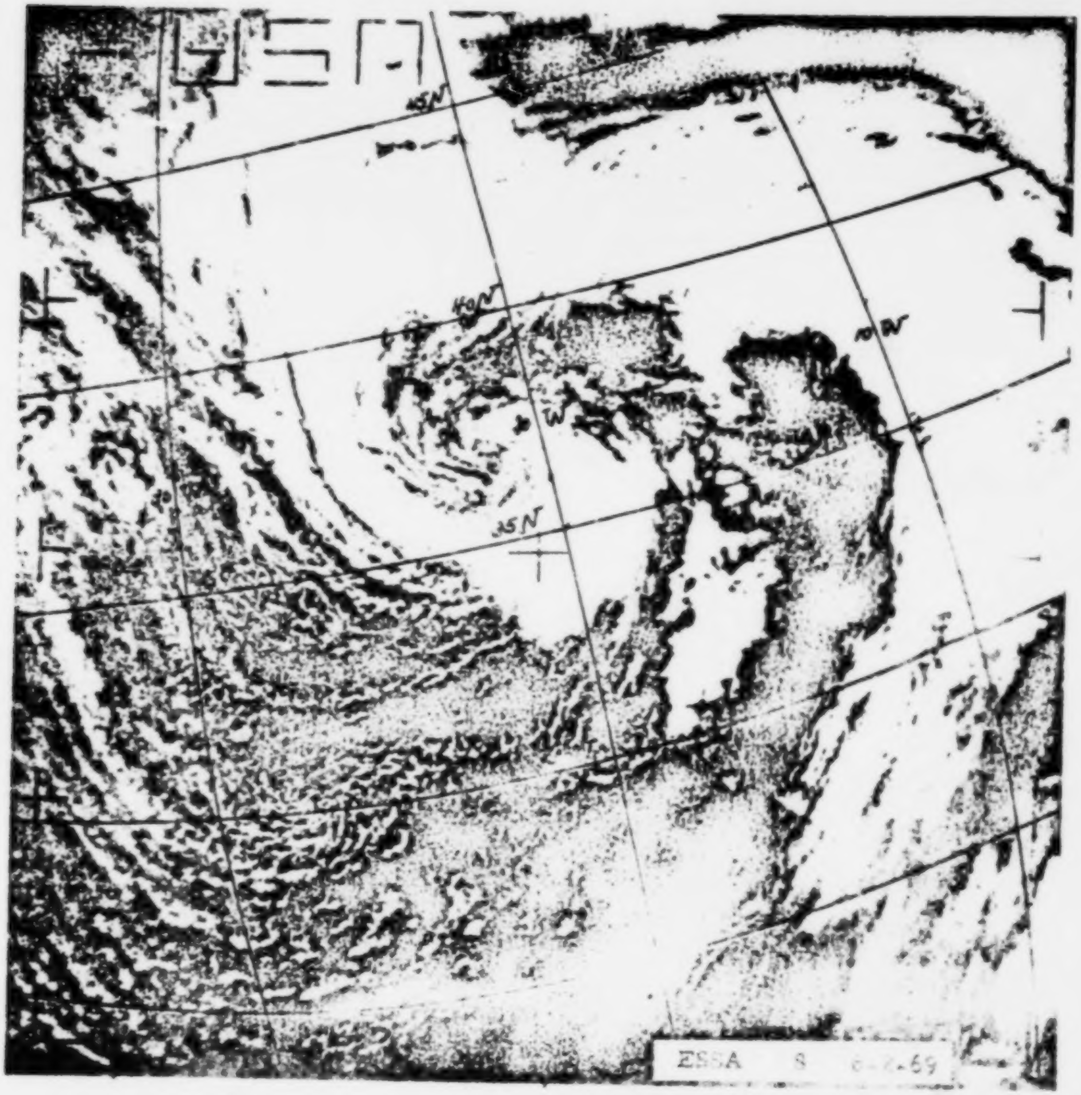
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FOTO KMI - UKKEL

PHOTO IRM - UCCLE

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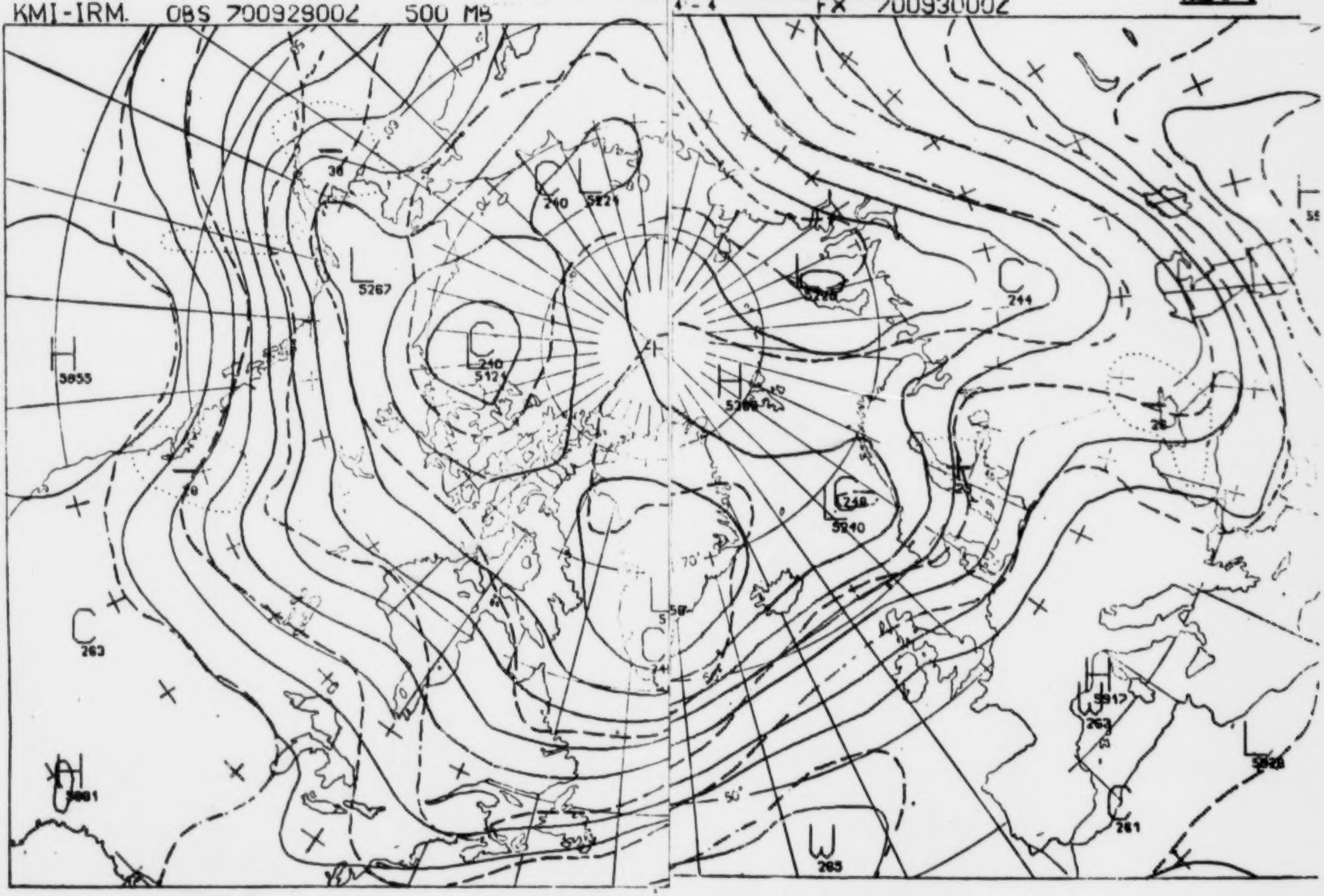
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AMENAGEMENT DE BASSINS FLUVIAUX

Pien et Vandervelden (Belgique)

Le problème se rapportant à l'aménagement de bassins fluviaux, traité par la Belgique, concerne le bassin de l'Escaut.

Une courte description de ce fleuve paraît nécessaire, étant donné que l'Escaut comporte une partie maritime, sujette à marée, et une partie fluviale, aménagée pour la navigation fluviale.

PARTIE MARITIME

Description

La marée de la Mer du Nord se propage dans l'Escaut maritime et ses affluents, le Rupel (avec la Nèthe inférieure, la Dyle et la Senne), la Durme et la Dendre canalisée. L'Escaut maritime et ses affluents sujets à marée, sont endigués sur toute leur longueur.

L'amplitude moyenne de la marée atteint 4,50 m à l'embouchure et passe par un maximum d'environ 5,00 m en amont d'Anvers. Cette amplitude a encore 2,00 m au barrage de Gand.

Le fond se compose principalement de sables fins et est, dès lors, très mobile.

L'Escaut maritime a la forme d'un bras de mer qui, à l'embouchure,à Flessingue en territoire néerlandais, a une largeur de 5 km et des profondeurs allant jusqu'à 40 m.

Le chenal se propage vers l'amont par une succession de courbes et contre-courbes séparées par des seuils.

A partir de la frontière belge, l'Escaut prend la forme d'une rivière, coulant entre deux digues plus ou moins parallèles, distantes de 2.500 m.

Devant Anvers, la largeur du fleuve n'est plus que de 400 m et entre la frontière belgo-néerlandaise et Anvers les profondeurs varient entre 10 et 18 m sous marée basse, tandis que la profondeur naturelle sur les seuils est d'environ 7 m. La distance entre l'embouchure et Anvers est d'environ 90 km.

Le débouché du Rupel se trouve sur la rive droite de l'Escaut à 15 km en amont d'Anvers. La rivière y a une largeur d'environ 300 m.

L'embouchure de la Durme est à 10 km en amont de celle du Rupel. A cet endroit la largeur de l'Escaut atteint encore 150 m.

En amont du débouché de la Durme et jusqu'au barrage de Gentbrugge arrêtant la propagation de la marée, l'Escaut a une longueur de 58 km sur une largeur diminuant progressivement jusqu'à 50 m ; il reçoit la Dendre canalisée à Termonde.

Aménagements

Dans la partie maritime du fleuve, les inondations sont provoquées par les marées-tempêtes, qui se propagent à partir de l'embouchure.

Des digues protègent les riverains contre ces marées.

Les terrains le long du fleuve, se trouvant un peu en dessous de la hauteur de mi-marée, sont en réalité des polders.

Après la marée-tempête catastrophique de 1953, l'Administration des voies hydrauliques a repris l'étude de la délimitation du danger d'inondation dans le bassin de l'Escaut.

Pour parer à ce danger, plusieurs moyens ont été envisagés :

- rehausser et renforcer les digues afin de les rendre non inondables ;
- construire dans l'Escaut en aval d'Anvers un barrage-tempête mobile, qui serait fermé lors de l'annonce de marées-tempêtes ;
- prévoir des bassins d'inondation (potpolders) ;
- ne pas rehausser les digues mais les renforcer de telle façon qu'elles puissent résister à la rupture et aux brèches, malgré un déversement intense.

Après un examen approfondi de ces moyens, l'Administration des voies hydrauliques en est arrivée à la conclusion qu'un rehaussement et un renforcement des digues le long du fleuve et de ses affluents sujets à marée, provoqueraient de tels soulèvements du niveau de la marée haute que de très importantes agglomérations (Anvers, Hemiksem, Niel, Boom et Rumst) où il n'est plus possible de surhausser les digues, risqueraient d'être inondées lors de marées-tempêtes.

La création de potpolders et l'aménagement de digues-déversoirs furent abandonnés parce que la superficie des zones inondables lors de marées-tempêtes extraordinaires est tellement réduite, que le stockage d'eaux déversées sur ces terrains ne permet pas un abaissement du niveau de marée haute.

Il en découle logiquement que la solution adoptée est celle de la construction d'un barrage-tempête, en aval de l'agglomération anversoise, mais situé de telle façon que l'accès du port (assuré par les écluses Royers, Van Cauwelaert, Baudouin et Zandvliet) restera en aval du barrage, tandis que l'agglomération anversoise pourra être protégée contre les tempêtes.

Pour éviter une fermeture trop fréquente de ce barrage, les digues en amont de l'ouvrage seront cependant renforcées et rehaussées à une cote leur permettant de résister à des marées de syzygie extraordinaires.

Il va de soi que les digues en aval seront rehaussées de manière à résister non seulement aux hauteurs des marées-tempêtes extraordinaires, mais aussi au relèvement du niveau des marées hautes provoqué par l'existence même du barrage-tempête.

PARTIE FLUVIALE

En aval de la ville de Gand, qui doit son existence au débouché à cet endroit dans l'Escaut d'un affluent très important, la Lys, se trouve un barrage barrant la marée dans le fleuve.

Les deux rivières ont une égale importance quant à l'évacuation des eaux et toutes deux sont, en territoire belge, canalisées par la construction de barrages-éclusés. Les grandes crues sont évacuées avec les barrages complètement ouverts et les eaux empruntent une partie de la vallée des deux rivières.

Ces zones d'inondation sont de plus en plus réduites par suite de l'accroissement des constructions dans ces vallées et de la densité de la population.

De ce fait les hauteurs d'eau, lors des crues, ne font qu'augmenter dans les rivières.

De plus, phénomène que l'on constate dans la plupart des pays, la quantité d'eau de surface récoltée dans le bassin hydrographique d'une rivière s'évacue plus vite que dans le passé.

En effet, au cours des dernières périodes décennales, on a constaté que par le drainage et l'amélioration des terres agricoles, par les revêtements de routes qu'elles soient de l'Etat, provinciales ou communales, par la construction de réseaux d'égouts, les débits instantanés s'évacuent plus rapidement vers le cours d'eau principal, de telle manière que les hauteurs d'eau y ont sensiblement augmenté.

Ainsi on a relevé en 1965 par rapport à 1925, avec une hauteur de pluie sensiblement inférieure à celle de 1925, une hauteur d'eau supérieure de plus d'un mètre dans l'Escaut et dans la Lys.

Cette intervention artificielle de la part de l'homme, qui a provoqué un accroissement des hauteurs d'eau dans les rivières, nécessite en compensation une nouvelle intervention artificielle permettant en même temps de régler l'évacuation des eaux.

Cette intervention pourrait consister dans la création, dans la partie supérieure des affluents du cours d'eau principal, de bassins d'attente qui, en périodes de grande crue, emmagasinent temporairement l'eau. Ces eaux seront évacuées après la fin de la crue dans le cours d'eau principal.

Il est possible d'envisager, pour ces grandes quantités d'eau à stocker de préférence sur des terrains de moindre valeur agricole, une utilisation autre que leur évacuation, soit en les convertissant en eau industrielle, soit même, si un traitement s'avère possible, en eau potable.

La Belgique a quasi terminé une première réalisation en ce domaine.

En effet, dans le bassin hydrographique de la Lys un bassin d'épargne, d'une capacité de 7,5 millions m3 d'eau, a été érigé avec des produits provenant de l'élargissement et de l'approfondissement du canal maritime de Gand à Terneuzen. Les eaux de pluie de la période d'hiver provenant de plusieurs affluents de la Lys y seront stockées. Elles sont de qualité suffisante pour être utilisées comme eaux industrielle et potable pour la zone industrielle située le long du canal maritime Gand-Terneuzen, et comme eau potable pour l'agglomération gantoise.

Un second exemple de réalisation est fourni par l'assainissement de la vallée du Demer, affluent du Rupel, lui-même affluent de l'Escaut. Dans le bassin hydrographique de cette rivière une dizaine de bassins d'attente seront réalisés sur les affluents du Demer pour y emmagasiner les eaux en périodes de crue.

Un troisième exemple de protection d'une agglomération contre les inondations a été réalisé par la construction d'un canal circulaire autour de l'agglomération gantoise.

Des problèmes très ardus peuvent se présenter au point de rencontre dans un fleuve, d'une part par l'effet de la propagation de la marée et, d'autre part par l'évacuation des eaux de crue du bassin hydrographique. En effet, à cet endroit, l'évacuation des eaux de crue peut être fortement gênée par la présence d'une marée exceptionnelle. Aux environs de ce point de rencontre on devrait pouvoir disposer de suffisamment de zones d'emmagasinement pour les débits de crue, afin de ne pas mettre en danger les zones bâties.

Un tel point de rencontre se trouve à Gand et, comme la ville elle-même est parsemée de cours d'eau naturels, constituant le confluent de l'Escaut et de la Lys, l'agglomération était singulièrement menacée à chaque coïncidence de facteurs défavorables.

Pour préserver la ville du danger d'inondation, l'Administration des voies hydrauliques a creusé un canal à grand gabarit, reliant autour de l'agglomération tous ces cours d'eau et prévoyant en même temps une double, voire une triple issue pour les eaux de crue.

Ce canal circulaire a par ailleurs résolu le problème de la navigation difficile dans les cours d'eau sinueux à travers Gand et facilité le trafic routier, fortement handicapé par les nombreux ponts mobiles sur ces cours d'eau.

Aménagement du territoire

Il est créé un service spécial au sein du Département des travaux publics ; il a pour mission de dresser des plans régionaux d'aménagement.

A la demande de l'Administration des voies hydrauliques les zones d'inondation sont reprises sur ces plans comme zones "non aedificandi" ; à l'avenir toute construction nouvelle y sera défendue.

MESURES DE PREVENTION ET D'ALERTE

Pien et Vandervelden (Belgique)

PREVENTION

L'Institut royal météorologique de Belgique envoie les avis de tempête et de vent fort :

(1) à tous les ports de mer (Administration de la marine) pour commande des signaux visuels ;

(2) à Radio Ostende (PTT) pour les navires en mer ;

(3) aux installations portuaires d'Anvers ;

(4) à SIDMAR (Sidérurgie maritime).

Régions en Mer du Nord : Dover, Côte belge, Thames (Voir carte).

L'IRM est responsable pour :

(a) l'avis de vent fort (6 à 7 Beaufort) pendant 3 heures au moins.

L'annonce ne se fait pas plus de 12 heures avant le début prévu. Le commencement et la fin du risque sont annoncés ;

(b) l'avis de tempête (8 Beaufort ou plus)

L'annonce d'une tempête est faite le plus tôt possible, mais pas plus de 18 heures avant le début prévu. Les changements de direction du vent pendant la tempête sont annoncés au moins 3 heures et pas plus de 6 heures d'avance.

Les cônes de tempête sont hissés ou baissés pour annoncer le commencement et la fin du risque.

ALERTE

Partie maritime de l'Escaut

Lorsqu'une profonde dépression se développe au large des côtes de l'Europe et risque de provoquer une tempête en Mer du Nord, surtout une tempête de NO à O, l'IRM doit atteindre le service hydrographique de la côte (Ostende) pour expliquer la situation atmosphérique et donner son avis sur l'évolution probable et cela jour et nuit.

Ces données sont comparées aux caractéristiques des marées précédentes et à celles de la marée astronomique prévue. Le service hydrographique peut avec ces données prévoir une cote bien déterminée pour la première marée haute suivante.

L'expérience acquise au cours des 50 dernières années en matière de marées-tempêtes, nous a appris qu'il existe deux hauteurs d'eau, ce qui permet de répartir les possibilités de dégâts en trois zones dont une hauteur Z (+ 5.50), une seconde Z (+ 5.75).

Si la marée haute n'atteint pas la cote Z (+ 5.50), il n'y a pas d'alerte, l'expérience ayant en effet prouvé que les dégâts possibles sont minimes.

Si la marée haute atteint une cote située entre (+ 5.50) et (+ 5.75) toutes les autorités compétentes sont alertées et prévenues de la possibilité de danger en ce sens que si la tempête continue avec la même intensité, la marée suivante sera certainement dangereuse.

Si la marée haute atteint une cote située au-dessus de (+ 5.75), la marée sera dangereuse et des dégâts très importants sont à craindre.

Le système d'alerte comprend dès lors 2 phases :

(1) envoi d'un télégramme à toutes les autorités intéressées portant la mention "marée extraordinaire".

Ce télégramme indique aux intéressés qu'il ne s'agit pas encore d'une menace directe, mais qu'une vigilance accrue est nécessaire pour la marée haute suivante.

(2) envoi d'un second télégramme aux mêmes autorités, portant la mention "marée - tempête dangereuse".

Celui-ci déclenche le système d'alarme qui comporte la mise en activité de centres de surveillance, au nombre de 9. Ces centres sont indiqués sur le plan annexé. Ils groupent un délégué de l'armée et des spécialistes RTT, un délégué de la province, chargé de la protection de la vie humaine, et un ingénieur ou conducteur des ponts et chaussées, chargé d'examiner les dégâts après le passage de la marée-tempête.

A chaque centre de surveillance sont rattachés 4 à 7 secteurs dans lesquels les digues sont surveillées mètre par mètre, soit par les préposés des Polders, soit par la protection civile des communes, soit par des cantonniers soit par des gardes de l'Administration des voies hydrauliques, soit même par la police des communes.

Toutes les informations recueillies sont immédiatement transmises aux centres de surveillance et, de là, à la Direction locale de l'Administration des voies hydrauliques, qui les transmet à l'Administration centrale.

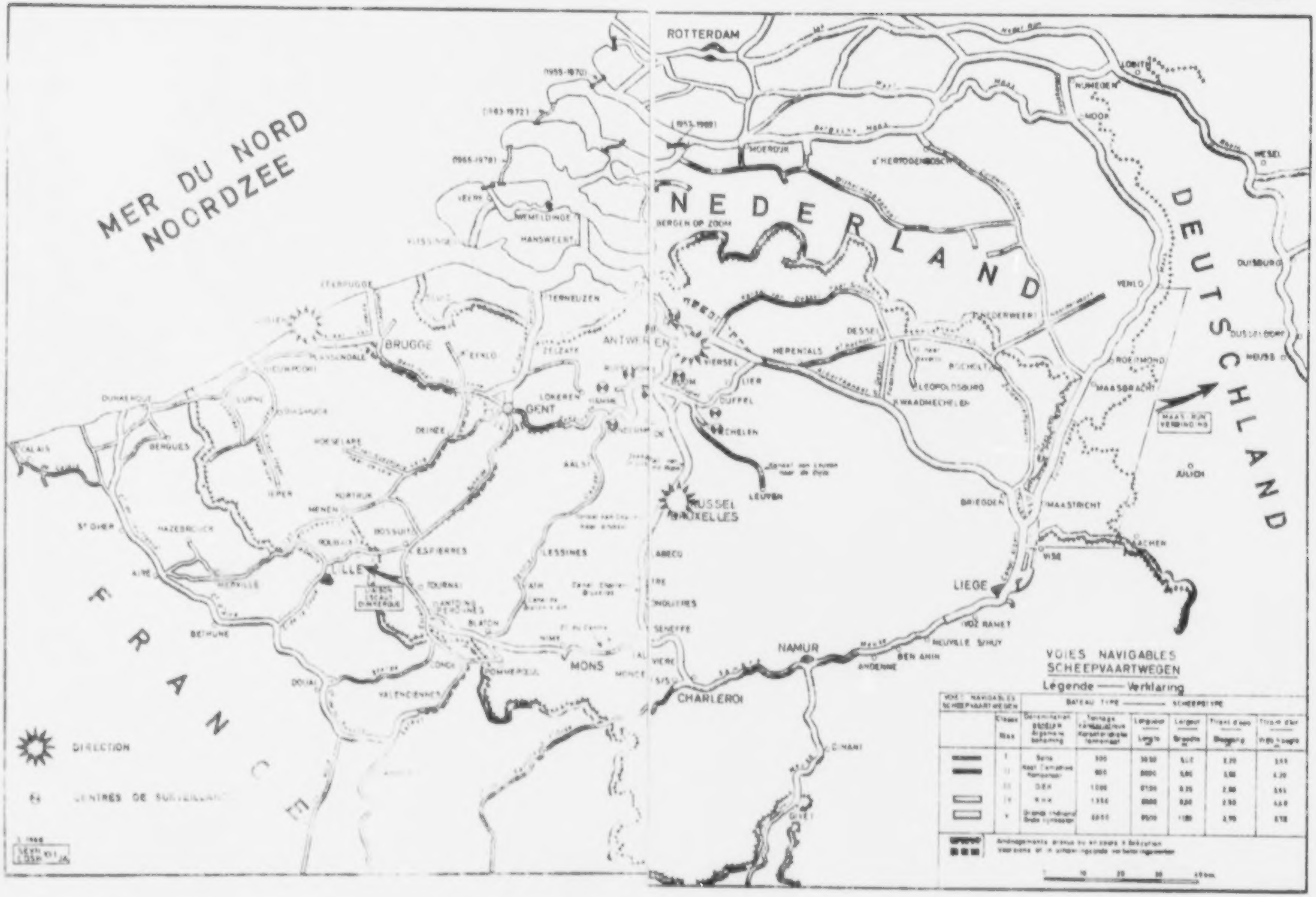
Partie fluviale de l'Escaut

L'Institut royal météorologique de Belgique envoie des télégrammes aux directions locales comme avertissement de danger d'inondation lorsque les pluies sont abondantes ou en cas de dégel rapide. Le commencement et la fin du risque sont annoncés.

L'existence de lignes privées de dispatching le long des cours d'eau sujets à des crues dangereuses permet à la Direction locale de s'informer à tout moment de l'évolution de la crue, de prendre les mesures qui s'imposent et d'avertir les Gouverneurs provinciaux et les communes riveraines du danger menaçant.

Pour l'amont du fleuve un contact s'établit entre les services français et les services belges.

CDSM Nº 2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VENLO
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MOLLIERES
VIESVILLE
VOIES NAVIGABLES
SCHEEPVAARTWEGEN
Légende —— Verklaring
BATEAU TYPE —— SCHEEPSTYPE
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DIRECTION
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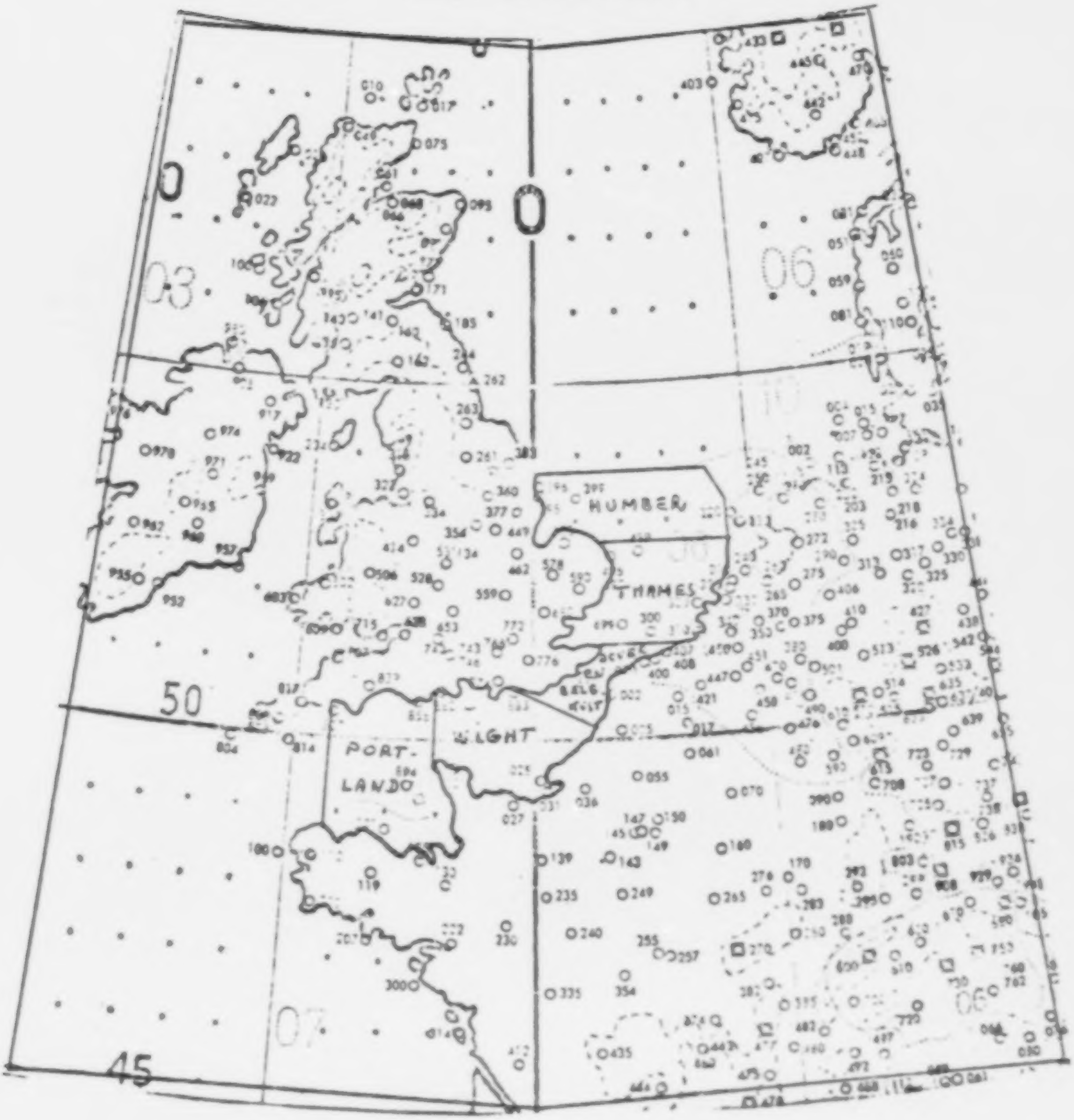
MARITIEME STREKEN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MESURES D'URGENCE EN PERIODE D'ALERTE OU EN PERIODE D'INONDATIONS PROVOQUEES PAR UNE MAREE-TEMPETE

Pien et Vandervelden (Belgique)

Selon les informations reçues au cours du passage de la marée-tempête et immédiatement après, il apparaîtra s'il s'agit d'une catastrophe ou de dommages normaux ou extraordinaires aux digues capitales.

Il s'agit donc de mettre le plus vite possible tout le matériel et le personnel à l'oeuvre pour réparer ces digues, car dès que la rupture ou la brèche est réparée, il est permis d'évacuer les parties inondées lors des marées basses.

Il faut signaler l'importance capitale d'une reconnaissance détaillée des lieux après le passage de la marée-tempête.

L'expérience a prouvé, que la réparation d'une petite rupture ne demande que très peu de temps, alors que la fermeture d'une grande brèche exige normalement plusieurs mois.

Une reconnaissance des lieux par hélicoptère est souhaitable, voire même indispensable.

(1) Il s'agit de dommages normaux

Des travaux d'urgence ne s'imposent pas. La réparation aux digues est à considérer comme travail normal d'entretien.

(2) Les dommages sont importants

Selon que la marée haute suivante est prévue dangereuse ou non, le chef de service local de l'Administration des voies hydrauliques décide la mise au travail ou non des entrepreneurs d'entretien et juge s'il est nécessaire de faire appel à l'armée.

(3) L'ampleur des dommages constitue une catastrophe

Les centres de surveillance mettent en route un programme bien déterminé :

- l'ingénieur ou le conducteur délégué du Département des travaux publics s'occupe uniquement de la réparation des dégâts occasionnés aux digues et fait appel, pour leur réparation, aux entrepreneurs et à l'armée ;

- le délégué du Gouverneur provincial s'occupe de l'aide à la population ;
- les délégués de l'armée s'occupent de l'approvisionnement en matériel et en personnel qui sont mis à la disposition de l'ingénieur ou du conducteur des ponts et chaussées dirigeant les travaux de réparation aux digues.

L'appel à l'armée et la désignation des endroits où elle doit opérer ne se font pas par les centres de surveillance, mais par la Direction locale de l'Administration des voies hydrauliques, qui centralise toutes les informations et répartit le matériel et le personnel disponibles entre les différents centres.

Les autorités communales n'interviennent jamais dans la réparation des digues. Elles peuvent faire appel à l'armée pour tous buts, autres que la réparation des digues, en accord avec le Gouverneur provincial.

La durée du maintien en service des centres de surveillance dépend de l'ampleur des dommages et est fixée après consultation et en accord avec l'Administration centrale des voies hydrauliques.

Un vade-mecum, contenant tous les renseignements au sujet de ce plan de mobilisation, donne également toutes informations utiles concernant les autorités intéressées (nom des responsables, adresse, numéro de téléphone, etc.).

B. INONDATIONS DUES A L'EVACUATION DES EAUX DE CRUES

Etant donné que ces inondations ne sont pas provoquées par des ruptures de digues, l'aide à la population inondée est du ressort des Gouverneurs de provinces.

Les travaux de réparation aux biens publics (ouvrages d'art, routes etc.) ne peuvent être entamés qu'après l'évacuation des eaux et ne présentent que des difficultés normales.

ORGANISATION DE L'AIDE MEDICALE URGENTE

Dr. Beckers (Belgique)

L'organisation de l'aide médicale urgente a été instaurée par la loi du 8.7.1964 et les arrêtés d'application.

- 16 centrales téléphoniques avec services de garde assurent une permanence dans tout le pays ; elles sont reliées par un numéro unique d'appel téléphonique (nº 900).

- Le transport des blessés ou malades est assuré par 293 ambulances, dont 23 avec système complet de réanimation, ainsi que par les ambulances des centres de la Croix Rouge, des organisations médico-sociales et privées.

  Le déplacement des ambulances est coordonné par les 16 centrales.

- 188 établissements hospitaliers avec services de garde sont agréés pour l'hospitalisation des urgences : ceci représente 54% des hôpitaux pour malades aigus (188 sur 354).

- 140 dépôts médicaux sont entreposés dans les différentes régions du pays afin de pourvoir aux premiers soins en cas de grandes catastrophes (inondations, explosions et autres).

- De plus, les 16 centrales avec services de garde possèdent un coffret médical avec médicaments spéciaux ou exceptionnels (sérum antitétanique, antidiphtérique, antibotulique, antivenimeux, ainsi que le BAL et autres).

THE RED RIVER FLOODWAY AND RELATED FLOOD CONTROL WORKS

by Thomas E. Weber (Canada)

The Red River Floodway is the major project in the eighty-five million dollar Flood Control Program presently underway in the Province of Manitoba. The Floodway, in conjunction with the Portage Diversion and the Shellmouth Dam on the Assiniboine River, will provide protection to Metropolitan Winnipeg within the main dyking system against a flood having a peak flow 60 percent greater than that recorded in 1950.

Metropolitan Winnipeg, with a population of approximately 500,000 is located at the junction of the Red and Assiniboine Rivers approximately sixty miles upstream of Lake Winnipeg into which the Red River discharges. The river's course lies in the basin of the prehistoric glacial Lake Agassiz. The river rises near the town of Whapeton, North Dakota, USA, approximately two hundred and fifty miles south of Winnipeg, and flows almost straight northerly on a gentle slope averaging one-half foot per mile. Due to the flat slope, the river has never cut a deep channel but flows in a shallow trough with no defined flood or secondary banks. The total drainage area at Winnipeg is 111,000 square miles of which 63,000 square miles are drained by its main tributary, the Assiniboine River. The remaining 48,000 square miles is the total area drained by the main stem of the Red River at Winnipeg. Of this area, 39,360 square miles are in the United States and 8,640 square miles are in Canada.

In 1950, the tragic flood which occurred on the Red River formed a lake in the valley south of Winnipeg, seventy-five miles long and twenty miles wide. The river rose in Winnipeg to an elevation of 30.3 feet (local datum), 12.3 feet above first flood stage. The flood waters inundated 10,500 homes and displaced 160,000 persons despite the heroic efforts of thousands of volunteer "dykers". The river remained above flood stage for a period of fifty-one days and "Operation Blackboy", a plan for the total evacuation of the city was ready if the river had risen another 1.3 feet.

The flood of 1950, as disastrous as it was, was not the highest on record. In 1861 a flood two feet higher than that in 1950 occurred; in 1852 one four feet higher; and in 1826 the water rose six feet higher. In 1956 it appeared that a flood of greater size than 1950 was in the offering, however, due to favorable weather conditions, the water only rose four feet above the initial flood stage. In 1965, the river rose to an elevation of 20.8 feet in the Winnipeg area but the absence of rain during the critical period prevented the water from rising to the predicted elevation of twenty-four feet.

The record-breaking blizzard that raged over the Red River Valley on 4th and 5th March, 1966 dumped an average of seventeen inches of snow on frozen ground which was already saturated due to the above normal precipitation of the previous fall. The break-up in the valley started earlier than usual and the potential run-off indicated a flood elevation of 29.5 feet (local datum) in Winnipeg. A return to colder weather in the early days of April slowed down the movement of the water into the main stem of the river and the elevation of the water only reached 26.3 feet on 15th April, just below the minimum forecasted elevation of 26.5 feet.

The design of the flood control works on the Red and Assiniboine Rivers was influenced by previous studies and investigations of these rivers. Following the 1950 flood, the Red River Basin Investigation, (R.R.B.I.) Water Resources Division, Engineering and Water Resources Branch, Department of Resources and Development of the Government of Canada was formed to investigate measures to reduce the flood hazard in Winnipeg. The investigation included a comprehensive study of the hydrology of past floods, analysis of flood run-off and feasible methods for flood protection. Preliminary design and cost estimates were prepared for channel improvements, diversions, dykes and storage reservoirs.

The report was submitted in October 1953 and included as an appendix the report of a similar study carried out by the Prairie Farm Rehabilitation Administration (P.F.R.A.) Department of Agriculture, Government of Canada, on the Assiniboine River. The terms of reference of the R.R.B.I. did not require a recommendation for the implementation of any works.

In December 1956, the Province of Manitoba appointed the Royal Commission on Flood Cost-benefit. The Commission was instructed to compare the costs with benefits which would accrue from the implementation of any of the schemes studied by the Basin Investigation or any other methods of flood control. In addition to engineering works, the Commission included in its studies a scheme for Government sponsored flood insurance. The report of the Commission was presented in December 1958 and in it the following projects were recommended:

1. The construction of a 60,000 cu.ft./sec. capacity floodway around Winnipeg.
2. The construction of a 25,000 cu.ft./sec. capacity diversion from the Assiniboine River to Lake Manitoba, near Portage la Prairie.
3. The construction of a storage reservoir on the Assiniboine River near Russell, Manitoba.

The Commission estimated the capital cost of these projects would be $72,483,000.00 (1958 costs) having a benefit cost-ratio of 2.73. The projects would provide complete protection for Metropolitan Winnipeg within the permanent dyking system up to a flood of 169,000 cu.ft./sec. measured below the confluence of the Red and Assiniboine Rivers with a frequency of occurrence once in 161 years.

The various projects of the recommended scheme of flood protection are now under construction except for the permanent dykes in Winnipeg which were completed in 1951.

Immediately after the 1950 flood, the Greater Winnipeg Dyking Board was established to construct a system of dykes in Winnipeg to provide a degree of protection for the city against flooding. Under the direction of the Board, a system of main line of defence against flooding from the Red, Assiniboine and Seine Rivers was established. In low areas, boulevard-type dykes were constructed, pumping stations installed to lift storm and sanitary sewage into the rivers, and established borrow areas from which material could be obtained to raise the dykes during a flood emergency. The profile of the top of the dykes was established approximately four feet below the maximum 1950 water level through the city. The minimum top width of the dykes is twenty-six feet to permit the raising of the dykes under emergency conditions an additional four feet. Under the terms of the Provincial Dyking Authority Act, the Municipalities in Metropolitan Winnipeg are responsible for the maintenance of the dykes, under the supervision of the Dyking Commissioner appointed by the Province. Since 1950 the primary line of defence has been extended or raised in conjunction with land development in the city. There are at present sixty-eight miles in the primary line of defence varying in maximum elevation between 26.5 and 32.0 feet with thirty pumping stations. In the spring of 1966, forty-two miles of the primary dykes were raised to an elevation of 31.5, involving the handling of approximately 600,000 cubic yards of material, between 21st March and 11th April, 1966.

The Portage Diversion, which the Commission recommended be built on a location running northerly from the Assiniboine River to Lake Manitoba on a route lying east of the city of Portage la Prairie, has been relocated. Further investigations on this project indicated that a more desirable route was one lying approximately two and one half miles west of the city of Portage la Prairie. This location would provide flood protection for the city as well as an additional section of the river below the city. The revised location will provide secondary benefits for irrigation, municipal water supply and wildlife. The reservoir created by the inlet works just upstream of the city will provide a source of water to supply a gravity canal running south-easterly to provide water in the Carman-Morris area in the Red River Valley. The route of the diversion lies to the west of a block of potential irrigable land which could be served; water can also be diverted as required to stabilize water levels in the marsh around the southern end of Lake Manitoba.

Lake Manitoba will serve as a storage reservoir for water from the diversion. Water can be returned through a proposed supply canal running southerly from the Lake near St. Ambroise to the river at Baie St. Paul. This water can be used to firm up the flow through the city as may be required for sewage dilution in the future.

The first contract was let on the Portage Diversion in the fall of 1965 and it is expected it will be ready for operation in 1970. The diversion will involve the excavation of approximately ten million cubic yards of excavation, the construction of a diversion dam, inlet and outlet structures with two gradient control structures in the channel. There are four road crossings and five railroad crossings along the 18.5-mile diversion.

The third project, which the Commission recommended, a dam on the Assiniboine River near Russell, Manitoba, has been relocated to a point on the river near Shellmouth, Manitoba. Investigations carried out by the P.F.R.A. subsequently to the Commissions's report, recommended that the dam be relocated at Shellmouth to avoid the flooding out of a railway line within the proposed reservoir. The Shellmouth Dam will provide a reservoir with an optimum storage of 340,000 acre-feet of which 150,000 acre-feet can be used for flood control operation. The reservoir will reduce flooding downstream, particularly in the vicinity of the city of Brandon as well as provide a dependable flow of 400 cu.ft./sec. in the river downstream of the dam.

The first contract on the Shellmouth Dam was let in 1964. The completion date is scheduled for the spring of 1969.

The Red River Floodway, the major project in the three-pronged flood control program is in the simplest terms, an earth channel to carry the flood flows of the Red River around Metropolitan Winnipeg from a point upstream of the city and return them to the river at a point approximately twenty miles downstream of the city.

In March 1959 the Manitoba Government announced its intention to proceed with the floodway as soon as the necessary detailed investigations and designs could be completed. Early in the spring of 1959, detailed surveys began to determine the final location, as well as investigations to relocate the inlet from a point near the south Perimeter Highway to a point upstream of St. Norbert. The Commission had suggested the revision, due to the increasing development between the Perimeter Highway and St. Norbert, as it felt that the increased benefits would justify the additional costs. The results of these investigations proved that such a relocation was justified and the present location of the floodway as shown in the figure was approved in 1960.

Detailed hydraulic investigations based on the various mentioned reports and on data collected in the intervening period were made to determine the conditions which would exist on the Red River and Assiniboine Rivers under natural conditions and with the recommended flood control works in operation. This information was developed to determine the water surface profile through the city as well as at the inlet and outlet of the floodway for the final design.

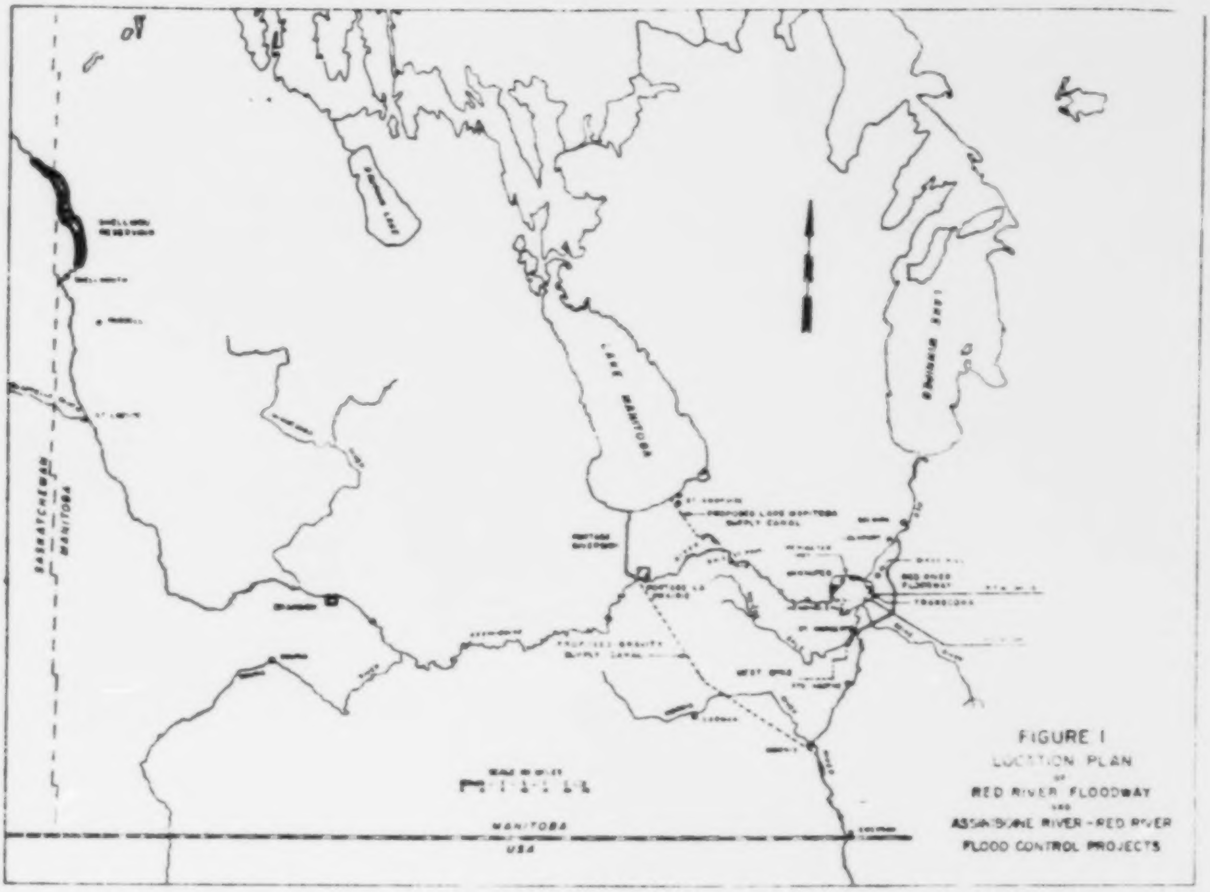

LAKE MANITOBA
LAKE WINNIPEG
SASKATCHEWAN
MANITOBA
MANITOBA
USA
FIGURE I
LOCATION PLAN
OF
RED RIVER FLOODWAY
AND
ASSINIBOINE RIVER - RED RIVER
FLOOD CONTROL PROJECTS

Figure 1 - Location Plan of Red River Floodway and Assiniboine River - Red River Flood Control Projects.

The Royal Commission recommended the 60-768 design of the Red River Basin Investigation as the desirable floodway capacity. This design would have a capacity of 60,000 cu.ft./sec. in the floodway when the water level at the inlet was 768.0 (G.S.C. datum 1928 adj.) but under design flood conditions would carry approximately 67,000 cu.ft./sec. The water surface profile under design conditions was calculated through the city assuming an initial storage of 150,000 acre-feet in the Shellmouth Reservoir; 25,000 cu.ft./sec. diverted at Portage; an average Assiniboine contribution occurring 90 percent of the time; and 67,000 cu.ft./sec. in the floodway. The resulting free-board on the city dykes was over two feet which was in excess of that considered necessary by the Commission. Therefore, the floodway design capacity was reduced to 60,000 cu.ft./sec. resulting in a free-board of one foot.

The Manning formula was used in the design of the floodway channel and the various factors in the formula were selected on the basis of available information and soil investigations carried out by the Branch. The prime consideration was that the water level in the river above the inlet control structure at design discharge would not exceed that which would obtain under natural conditions. The roughness coefficient (n) that was selected was 0.028. The maximum permissible velocity was selected as five feet per second.

The selection of side slopes was based on extensive analysis of existing natural and artifical channels in the Red River Valley, and detailed investigations of the soils along the route. Dr. A. Casagrande of Harvard University, acted as soils consultant on the floodway and recommended that 6:1 side slopes be used except in the granular material of the Birds Hill area where 2.5:1 slopes could be used. This latter slope was changed to 3:1 in the final design due to practical considerations. In the vicinity of structures due to economic and safety reasons, the side slopes were flattened to 9:1. Transition sections were incorporated in the channel at points of change in cross-sections and above and below structures where the side slopes were flattened.

In the selection of the most economical cross-section for the channel which would satisfy the design criteria, the estimated excavation costs were the important consideration as the estimated volume of one hundred million cubic yards of excavation represent almost half the total cost of the project. The R.R.B.I. and the Royal Commission used an excavation price of thirty cents per cubic yard for earth and one dollar for glacial till, these prices were used in estimates for the final design with the cost of the bridges being estimated by the constructing authority.

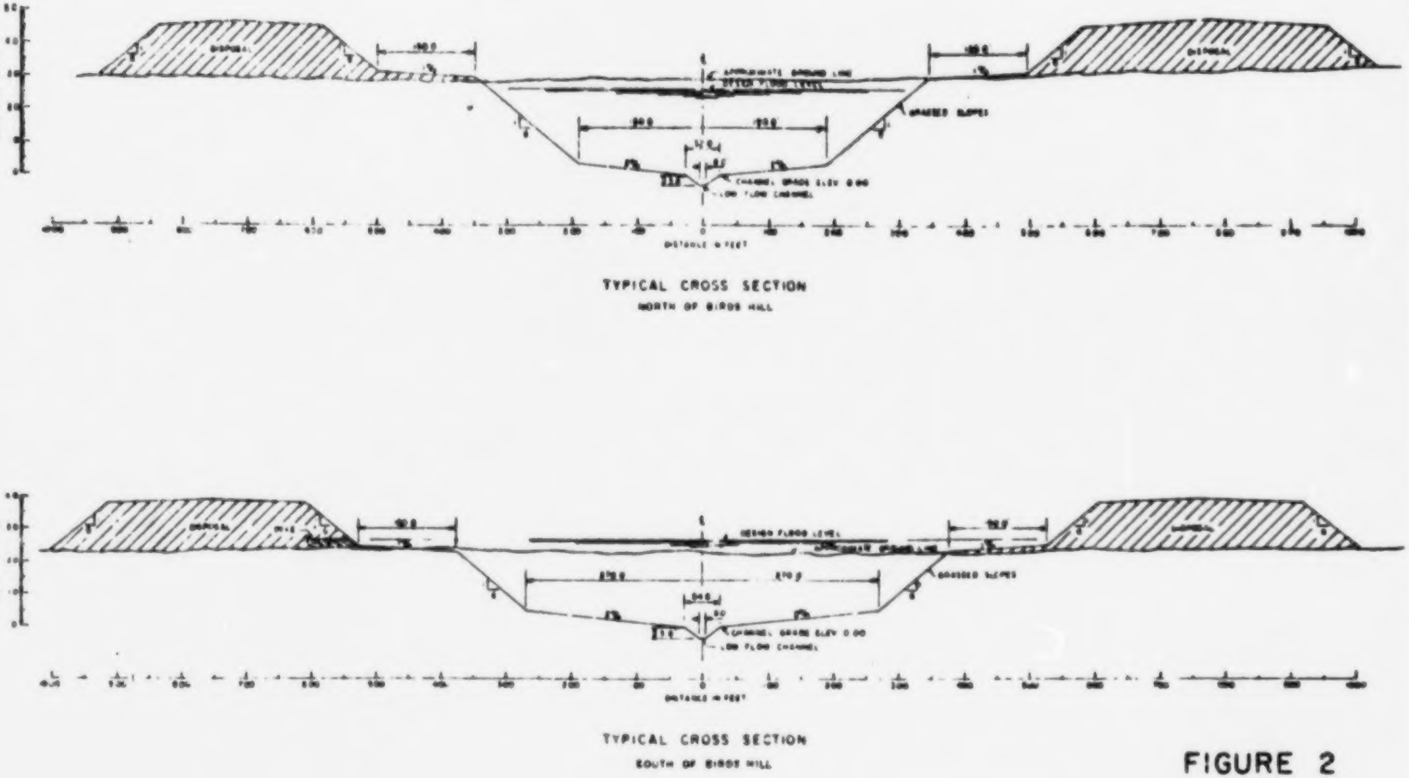

DISPOSAL
APPROXIMATE GROUND LINE
GRADED SLOPES
CHANNEL GRADE ELEV 0.00
LOW FLOW CHANNEL
DISTANCE IN FEET
ELEVATION IN FEET
TYPICAL CROSS SECTION
NORTH OF BIRDS HILL
DESIGN FLOOD LEVEL
TYPICAL CROSS SECTION
SOUTH OF BIRDS HILL

FIGURE 2

RED RIVER FLOODWAY
TYPICAL CROSS SECTIONS

Figure 2 - Red River Floodway Typical Cross Section

The IBM 1620 data processing system was used to compute accurately the backwater curves and earthwork calculations, on ten designs selected from about fifty preliminary designs in which approximate calculations were used. The variations in the cost of ten designs were only about 2 percent. The choice wes finally narrowed down to two designs, one with a wider but shallower cut, the other with a deep cut and small channel cross-section. The shallower channel was selected in view of the probable reduced costs and difficulties which could result during construction and maintenance of a narrow deep channel. A small channel with a capacity of 100 cu.ft./sec. is incorporated in the cross-section to confine the low flows from the Seine River and adjacent local drains intercepted by the Floodway to the centre of the channel. The final cross-sections are shown in figure 2.

The floodway section will consist of a broad 700 feet wide earthen weir with a crest elevation of 750 at the river and a transitional section expanding to the normal floodway cross-section. The summer and spring flows below 30,000 cu.ft./sec. will pass down the Red River without entering the floodway.

At the inlet, without control works in the river, the flood flows would split between the river and the floodway resulting in a drawdown of approximately eight feet at the inlet. This drawdown would dictate a larger channel, however, with control works in the river the natural water levels can be maintained and the water entering the floodway regulated.

The inlet control structure consists of two submerisble modified sector steel gates each 112.5 feet long and 34.9 feet high, supported by two concrete abutments and centre pier. The weir crest in the structure is at elevation 728.0 which is approximately six feet below the controlled summer river level on the Red River. There is a traffic bridge located over the structure and an operating control room is located on the centre prier at bridge deck level.

At design discharge the water surface profile in the floodway at the outlet will be fourteen feet above the level in the river. A control structure was therefore necessary to dissipate the energy to ensure that scour above that which would occur under natural conditions does not result in the river channel below the junction.

The design of the inlet control and outlet control works was carried out by H.G. Acres and Company Limited, Consulting Engineers, and model studies for these two structures and the floodway inlet sections were carried out at the University of Manitoba under the direction of H.G. Acres for the former and the Water Control and Conservation Branch for the latter.

One of the basic design criteria for the floodway was that natural conditions at design flow must be maintained upstream of the inlet in the Red River. Flooding will, therefore, occur in the valley upstream of the inlet. The construction of a dyke, tied into the inlet works, and extending approximately twenty miles west, varying in height from twenty to two feet as required to prevent the flood waters entering the city from the south-west.

In addition to the dyking on the west side, during design flow the water surface will be above the prairie level in the floodway extending for a distance of approximately six miles downstream of the inlet. The dyke in this section has been incorporated in the disposal areas on the west side of the floodway.

The floodway will intercept numerous natural and artificial waterways. Due to the difference in elevation between the bottom of these channels and the floodway bottom, drop structures are required. In order to reduce the number of structures, a collecting drain has been designed on the eastern limit of the floodway right-of-way with entrances into the main channel at selected locations. There will be six local drainage inlet structures along the floodway.

At the point where the Seine River crosses the floodway, a siphon will be constructed under the floodway to carry approximately 100 cu.ft./sec. of the Seine River flow. The balance will be taken into the floodway through a drop structure.

Bridges over the floodway were designed by the various authorities. The Water Control Branch provided the hydraulic requirements at each location, approved the plans, and are responsible for contract administration. There are seven railway crossings and six highway crossings.

The floodway crosses the two branches of the Metropolitan Corporation of Winnipeg aquaduct. Similar arrangements were made for the lowering of the aquaduct as were made with the bridges. There are six hydro transmission lines crossing the floodway, one oil pipeline and one gas pipeline. Communication lines across the floodway have been incorporated in the various bridge crossings.

In planning the construction of the floodway, detailed investigations were carried out as to the possibility of employing hydraulic dredging. Consideration of dredging appeared favorable in the earlier stages due to the expected difficulties of operating conventional equipment at the design depths of the channel. However, it was decided that dredging was not feasible due to (a) the difficulty of handling the lacustrine clays, and (b) the low volume of water which would be available from the Red River. In the fall of 1961, a full scale test pit was constructed to determine slope stability as well as the ability of equipment to work in the highly saturated clays above the glacial tills. In addition, a smaller test pit was constructed to determine the best method for the removal of the cemented glacial till (hard-pan) in the area north of Birds Hill.

In the planning for the construction schedule, the floodway was divided into twelve reaches. The various items of work in each reach were then scheduled to ensure the proper co-ordination between the various co-operating agencies and contractors. The critical path method of scheduling the work was employed to advantage in this phase of the planning. The bridges were constructed in the dry by excavating to approximately one-third the ultimate depth at the bridge site completing the bridge and then having the earth contractor remove the remaining earth to the design channel depth. The excavation contracts average one and one-half miles in length with an average of 4.3 million cubic yards of excavation. An earth block is left between each contract and provision is made in every contract for an outlet drain for disposal by the contractor of surplus water in the excavation. Each contract provides a clause so that the removal of the block at either end of a contract may be added to the excavation at the contract unit price.

To 31st December, 1966, twenty-three excavation contracts have been let involving 96,000,000 cubic yards of excavation completed. In the contracts the unit price for excavation includes the removal and disposal of all material either clay or glacial till as encountered by the contractor. The minimum price was 18.9 cents per cubic yard, the maximum 41 cents with the overall average being 29 cents per cubic yard.

During the excavation of the test pit in the lacustrine clay, ground water flows were encountered. This flow was derived from an artesian aquifer in the limestone underlying the till and clay. Potential groundwater seepage was therefore indicated where the elevation of the base of the channel would be close to the limestone. A hammer seismic refraction survey was carried out to supplement bore hold information to prepare a bedrock profile and thus outline reaches where seepage could be expected.

During the construction of the channel and bridge piers in the reach of the floodway between P.T.H. 15 and Birds Hill, serious groundwater seepage has occurred. The contractors have therefore been required to carry on extensive pumping operations and in so doing have lowered the water surface of the aquifer. These operations have affected approximately 185 private wells in the vicinity of the floodway and where the drawdown in the vicinity of the wells exceeded two feet or more, as determined by one of the thirty-six permanent observation wells, the Province has restored the flow from the private well. This work consists of either the extension of the well or, in the case of deteriorated wells, the Province has assumed at least fifty percent of the cost of drilling a new well to obtain water. This policy has received general acceptance in the area and to date has avoided any legal action on the part of the owners.

A special Floodway Property Committee was appointed, composed of three members and a staff of appraisers and negotiators to carry out the acquisition of the right-of-way for the floodway. There are approximately 14,800 acres of land in the right-of-way involving 560 parcels of land. The total cost of the right-of-way is estimated at seven million dollars and the land purchased included a wide spectrum of land types from residential building lots through to swamp land.

In 1960 the total cost of the floodway was estimated at $63,212,000.00; to date expenditures have amounted to fifty-seven million dollars and indications now point to the final cost falling within the 1960 estimate. The floodway is being constructed by the Province under a Federal-Provincial Agreement in which the Federal Government contributes thirty-seven and one half percent of the cost of excavation.

AN INTEGRATED SYSTEM OF FLOOD FORECASTING AND RIVER CONTROL IN THE PROVINCE OF ONTARIO, CANADA

by D.N. McMullen (Canada)

Introduction

In a number of countries throughout the world, the river forecast service is distinctly separate from the agency responsible for river control permitting each group to develop their own program for the solution of their individual problems. In Canada, however, particularly in the Province of Ontario, the opposite approach has been taken by combining the two activities, river forecasting and river control, within one organization and thereby obtaining a unity of purpose and involvement in all aspects of the river.

This combination has two very beneficial features. First it ensures that weather forecasting procedures and hydrometeorological techniques are incorporated into dam construction and water management programs at all stages - design, construction and operation. Second, it guarantees a complete correlation of river forecast and dam operation whereby forecasts are based on operation procedures while at the same time operation procedures are adjusted to forecasts.

The paper discusses a number of features of this integrated system of flood forecasting and river control along with pertinent information on such items as topography, climate and organization as required to put the program in the context of Ontario.

Water Régime

1. Location and Topography

Attention is directed primarily to that section of Ontario covering some 30,000 square miles between longitudes 74 and 83 west and latitudes 42 and 45 north. This is the most heavily populated region of the province. Apart from the highly industrialised urban areas, the region is mainly agricultural land but with some forested areas to the north. The topography varies from hilly to flat with elevation above sea level ranging from 200 to 1,700 feet.

All drainage basins are relatively small with the largest having an area less than 3,000 square miles. No major river system is developed in this region as each watershed drains into the Great Lakes. The headwaters of the streams and rivers are in the hill and plateau districts so that the run-off is very rapid, creating flood conditions on most of the rivers within a few hours after rain has fallen.

2. Climate and Run-off

The average annual precipitation varies across the region from 30 to 40 inches and is equitably distributed throughout the year; averaging about three inches per month. Snowfall is general from November through March with average annual amounts varying from 40 inches in the south up to more than 100 inches in the plateau area to the east of Lake Huron. During the winter months, periods of rain are not uncommon.

The average annual run-off ranges from 12 to 18 inches with 50 to 60 percent occurring in the period from March to early May. With warm temperatures and lush vegatation during the summer, the evapotranspiration is high causing streamflow to drop to a very low level.

Spring floods caused by either snowmelt, or mixed rain and snowmelt, or rain on saturated ground are a common occurrence in this region. During the summer months, intense thunderstorms occasionally create floods on small drainage basins. In the late summer and fall severe floods are caused at infrequent intervals from the intensification of extra-tropical weather systems by dissipating Atlantic hurricanes.

Organization

1. Conservation Authorities

Conservation Authorities in Ontario are local bodies working in conjunction with the provincial government and are responsible for river control and water management on their own watershed. Technical and financial assistance is given to these Authorities by the Ontario Government through the Conservation Authorities Branch of the Department of Energy and Resources Management. (For detailed information on this program see, "Conservation Authorities in Southern Ontario", by A.S.L. Barnes, Conference on Water for Peace.)

By means of the Conservation Authorities, a comprehensive program for management and control of water has been established on all watersheds of Southern Ontario. Under this program, water use and management are directed locally by the Conservation Authority to meet the requirements of the particular watershed, while flood forecasting and flood control, which are more regional in scope, are controlled by the central office of the Conservation Authorities Branch through regional flood control centres.

2. Flood Forecast Service

The continual threat of floods and their consequent danger to life and property necessitated the establishment of a Flood Forecast Service in Ontario. This was done by combining the relevant responsibilities of the Canadian Meteorological Service (a Branch of the Federal Government) within the program of the Conservation Authorities Branch of the Ontario Government. To handle this co-ordination, a hydrometeorologist was loaned by the Meteorological Service to the Conservation Authorities Branch to be responsible for flood forecasting throughout the province.

As a consequence of this co-ordination over a number of years, the Engineering Division of the Conservation Authorities Branch has developed a comprehensive program in the field of watershed management based on a broad range of competence in hydraulics, hydrometeorology and allied disciplines.

Dam Design and Reservoir Operation

The Conservation Authorities have been involved in a broad-scale dam construction program for many years with the Engineering Division of the Branch having the responsibility for the design, construction and control of these dams.

An important feature of this program is that all the reservoirs are developed on the basis of multi-purpose use of water. These uses, which include flood control, urban water supply, irrigation, pollution abatement, maintenance of flow and recreation, are often incompatible and as a consequence create many operation problems not encountered in the single-purpose reservoir.

A flood control reservoir requires empty storage space for flood waters; a water supply reservoir should be full at the beginning of the season with drawdown taking place through the season; a recreation reservoir requires a constant level throughout the summer season. To co-ordinate such uses within one reservoir requires that flood routing techniques and reservoir operation procedures be thoroughly established at the design stage to ensure that the hydraulic characteristics of the structure effectively meet those procedures.

It is also of importance that reservoir operation procedures be established within the realistic capabilities of flood forecast service. Without this consideration the efficiency of the reservoir for its various uses is decreased markedly, or alternatively, the safety of the structure is imperilled.

As an example of these requirements consider a multi-purpose reservoir for flood control, water supply and recreation which has only limited storage capacity in relation to the potential flood run-off from the basin. Starting with an empty reservoir at the beginning of the spring run-off, the pattern of discharge must be established on the basis of the forecast run-off pattern in order to reduce the peak flows as much as possible. These high flows from snowmelt usually cover a protracted period so that only limited reduction is possible. The use of the reservoir storage at this time must also be apportioned on the premise of rainstorms occurring in conjunction with the snowmelt run-off. After the release of excess water from flood storage, the water level in the reservoir is set at the holding level for water supply and recreation. Procedures based on the gradual drawdown of water, within the limitations imposed by recreation, then come into operation. As autumn in Ontario has a high flood potential, reservoir drawdown must continue on schedule to insure the availability of flood storage space at the end of summer. At all stages in the reservoir program, operations are more efficient when closely tied to river forecasts.

It is worthy of note, that in a multi-purpose reservoir system the releasing of stored water before a storm, to gain additional flood control storage without compromising the other water uses, is an extremely difficult decision which can only be made on the advice of a dependable forecast service.

A thorough examination, during the design stage of the dam, of the hydrometeorological factors of the watershed as they affect the multi-uses of the reservoir, has proven to be a valuable means of improving the effectiveness of the operations. By such a study, control works can be designed to support the operation requirements.

To ensure this effectiveness of operation and the safety of the structure, a manual of operation procedures is established for each dam. In this way all persons connected with the operation of the dam are made fully aware of the procedures. The operating procedures include "rule curves" which define release rates dependent on the rate of rise of the water level in the reservoir; water holding levels for recreation and other uses; and water release programs for water supply and downstream pollution abatement.

These procedures are established by the Engineering Division of the Branch in line with the water management policies established by the local Conservation Authority.

The actual operation of the dams is directed from regional control offices, handling one or more watersheds, which are under the direct control of the Branch's central Flood Forecast and River Control Unit.

Flood Forecasting

The first step in the warning program is the issuance, in anticipation of a flood, of a Flood Advisory by the Flood Forecast and River Control Unit to the regional control offices. This insures that all operating staff are alerted to the emergency. The regional offices advise the dam operators as well as alerting the Works Department of the towns and cities within their region. These Works Departments are responsible for taking protective action along the rivers and streams as required.

When the full potential of the flood becomes evident, hydrographs are prepared for all affected streams and rivers based on anticipated snowmelt run-off or rainfall. These hydrographs are routed through the flood control reservoirs on the basis of the designated operation procedures. The regional offices are then supplied with the routed forecast hydrography and given advice on any supplementary operation procedures by which more effective use can be made of the available storage in the reservoir. The operation procedures for the full flood period are then reviewed by the regional office with the dam operators to make certain that all operations are known and clearly understood.

Flood forecasts are then issued to the public by Press, Radio and Television giving information on the expected flood stage and the time and period of flooding at major locations along the rivers.

During the flood, the Flood Forecast and River Control Unit maintains a close watch on all meteorological information and streamflow data, adjusting forecasts and operation procedures as required to fit unforeseen developments. It is a basic understanding, however, that in the event of a major breakdown of communications, the operator of the dam follows the operation procedure laid down in his manual until communications are restored. This procedure ensures safety of the structure under all conditions while at the same time giving some reduction to flood flows.

Conclusion

It has been found, through operation in the Province of Ontario, that an integrated system of flood forecasting and river control is most valuable in increasing the efficiency, for flood control, of multi-purpose reservoirs while improving their effectiveness in all aspects of water management.

The combination of flood forecasting and river control within the organization responsible for the design, construction and operation of dams also ensures a continued feed-back of information to improve future units in the system.

ICE AND RIVER CONTROL

by John B. Bryce (Canada)

Introduction

The successful control of ice on relatively fast-flowing rivers developed for hydroelectric power and subject to low winter temperatures, often presents many varied and difficult problems. Two such rivers are the Niagara River flowing from Lake Erie to Lake Ontario, and the St. Lawrence River flowing from Lake Ontario. It is on these international rivers that large hydroelectric developments have been built by the Power Authority of the State of New York and the Hydroelectric Power Commission of Ontario, and where complex, important and in some cases unprecedented, problems in ice and river control have occurred, and are still occurring. Herein is a description of the ice problems encountered, and the most significant measures taken to achieve control of these rivers in the wintertime. The experience described may be of some assistance in the solving of similar ice problems elsewhere.

St. Lawrence ice problem

General nature of ice problem: In northern rivers subject to ice problems, if a stable ice cover can be formed on the channels leading to a hydroelectric plant, then normal operation can usually continue throughout the winter, and few ice problems occur. However, problems arise when a cover cannot be formed or maintained, due usually to high water velocities, and when surface, frazil, and anchor ice form on the open-water area, and cause jams downstream. The St. Lawrence River fell over 80 ft. in the 40-mile International Rapids section, the fall being mostly concentrated in three rapids areas. These areas stayed open all winter and, because of the low temperatures experienced, generated large volumes of ice and massive jams usually formed downstream from the rapids. To those, over the years, who planned the St. Lawrence development for power and navigation it was a matter of considerable concern whether the operation of the hydroelectric plants in the winter could take place without serious ice jams blocking the river. These problems were overcome by designing the channels so an ice cover would form over most of the head-waters, and by the use of ice booms in the upstream reaches.

Channel design for ice cover by packing

River velocities: The St. Lawrence Project Dams raised the river level over 80 ft. just above Cornwall, and the flooding extended upstream 40 miles to the head of the Galop Rapids. For approximately 20 miles, to Morrisburg, the flooding was sufficient to provide velocities low enough to assure that an ice cover would form in place by freezing and packing. From Morrisburg to below Cardinal, however, approximately 11 miles, the velocity without any channel enlargement would be moderately high, and it would be unlikely that a cover would form. Through the Galop Rapids and upstream, velocities approaching natural would occur without enlargement, and an ice cover would not form.

Channel enlargements: In earlier years, many studies were made at the St. Lawrence River and elsewhere to determine the conditions necessary to enable an ice cover to be formed by packing. Packing takes place when ice floating down a river comes to rest against a stationary ice sheet and is not drawn under by the velocity; the cover is thus extended upstream. As early as 1926, it was concluded by the St. Lawrence River Joint Board of Engineers in their report on the St. Lawrence Project that under St. Lawrence conditions the mean velocity in a cross section should not exceed 2¼ ft./sec. if packing were to be achieved. In the applications of the Governments of Canada and the United States to the International Joint Commission, and in the subsequent International Joint Commission Order of Approval it was stipulated that velocities should not exceed the foregoing figure in any cross section from Morrisburg to below Cardinal under regulated conditions expected at ice-forming periods. Through the Galop Rapids and upstream, however, because of the prohibitive excavation that would be required to produce similar velocities, enlargements were required only to provide velocities not exceeding 4 ft./sec. under navigation conditions. The channels were enlarged to satisfy these criteria.

Experience with channel enlargements: The channels designed to provide not more than 2¼ ft./sec. at ice-forming periods have proved to be eminently successful in producing an ice cover. In each of the nine winters from the inception of the project to date, a satisfactory ice cover has formed by packing, and normal operation has been carried on under the ice cover without incident. There is some evidence that the velocity stipulated is close to the maximum, as under certain wind and temperature conditions a cover might not have formed and been maintained had the velocity been appreciably higher. Note that experience with ice booms corroborates that, in general, ice covers cannot be formed and maintained above booms if the velocity exceeds appreciably this same figure.

Experience with the channels through the Galop reach and upstream in the first winter of operation, however, was anything but satisfactory. Velocities in the Galop channel were in the order of 3 ft./sec. at ice-forming periods, and in some areas upstream from the Galop approached this figure. In this first winter, ice formed to the foot of the Galop channel as expected, but no further upstream. All ice formed in the open Galop Channel and upstream, passed under the leading edge of the cover forming a large hanging dam. Periodically ice formed in the upper channels would break lose, flow down the Galop channel, and join the jam. Ice from a 15-mile reach in the upper river broke up two times under storm conditions, and also came down. At one time the blockage from the jam was sufficient to reduce the flow in the river by approximately 50,000 cu.ft./sec. or a quarter of the total. Only careful operation and the coming of spring prevented a more serious blockage. It had been anticipated that further ice-control measures (e.g. ice booms) would be required in the Galop and upstream, and the first winters operation fully confirmed this.

St. Lawrence Ice Booms

Assessment of Problem: There was no possibility of forming a cover in the Galop channel proper because of high velocities. In the 5-mile reach between the head of the Galop and Prescott-Ogdensburg, however, ice covers did form near the shores, and at times across the river, but were unstable and tended to move and flow downstream. It was felt that ice booms might be successful in producing a stable cover in this area. Also, a boom at Prescott might prevent the upper-river ice from breaking up, and discharging downstream under storm conditions. Observations during the first winter suggested that the river under the ice cover could safely digest (i.e. store there without significantly blocking the river flow until removal by erosion or melting) a considerable amount of ice such as that formed in the Galop channel only, but blockages occurred when the upper river ice also was added. It was hoped that if booms could reduce the ice to be digested to that formed in the Galop, then a solution might result. Hydro Quebec, who had pioneered in the development of ice booms in the St. Lawrence, freely made its design and operating experience available, and this assistance was invaluable in design of these books.

Location of Booms: The reach upstream from the Galop was studied intensively utilizing both field information and information from a large model of the area, to determine the optimum location for the booms. Booms A to E were installed in 1959, their function being to stabilize and prevent movement of the upper-river ice and the ice that formed in the bays and side channels. It was hoped that this action and the consequent reduction in open water in which ice would be produced would be sufficient, but it was recognized that an open channel of relatively high velocity would continue to exist in the middle of the reach. During the winter of 1959-60, the booms performed as planned and no discharge of upper ice occurred. However, the open-water area was still too large and the production of ice in this area continued to be greater than could be digested under the downstream ice cover. In 1960, Boom G was installed to eliminate this open area even though it was realized that the velocities at this boom were higher than desired. In Table 1 is summarized the length, depth and velocities at the six St. Lawrence booms.

TABLE 1 - BOOMS

	A	B	C	D	E	G
Length, in feet	5,100	2,100	2,250	2,250	1,780	3,350
Mean Water Velocity at Boom, in feet per second model	0.95	1.90	1.85	1.40	1.60	2.75
Mean Depth at Boom, in feet	49	22	27	17	22	24

St. Lawrence Ice Boom Experience: Since the complete installation of the booms in 1960, the ice problems at the St. Lawrence Project appear to have been solved. The booms provide a stable cover upstream from the Galop channel, and the remaining open-water area does not produce more ice than can be digested without blockage downstream. The experience gained in the locating, design and operation of the St. Lawrence booms is summarized below:

1. Relationship with Topography

Ideally, the boom should be located so that once a consolidated cover has formed, it will become locked or keyed to the land. This can be achieved by selecting sites with irregular or converging shores or where islands can serve as anchors. In such locations, forces tending to move a consolidated ice sheet would be resisted principally by the land rather than by the boom. Observations at the St. Lawrence confirmed this conclusion; and, indeed, at times there is no load on some of the booms after the ice sheet consolidates.

2. Water Velocity

Booms A, B, C, D and E have all performed satisfactorily in each winter to date. Boom G, located unavoidably in a relatively high-velocity area, with the mean velocity along the boom 2.75 ft./sec. and with spot velocities to 3 ft./sec., now operates satisfactorily. However, to achieve this result, a relocation from its original position was necessary after the first winter of operation, to provide a greater obliquity to the flow and stronger anchorages. It is believed that this boom is near the velocity limit for satisfactory operation. It is concluded that booms under St. Lawrence conditions will operate satisfactorily when the mean velocity is 2½ ft./sec. or less, but above this value and certainly at 3 ft./sec. or greater, the ice sheet will prove unstable.

3. Strength Considerations

In designing the ice boom it might seem necessary to allow for the maximum thrust which the upstream ice sheet could produce under severe wind conditions. Such a maximum thrust is dependent upon so many factors that it is indeterminate and fortunately irrelevant to the design of a successful boom of the type described herein. At both St. Lawrence and Niagara, a moderate amount of ice can be spilled over the boom without detriment. This makes it feasible to design the boom structure to resist only the load which causes the boom to submerge. If during the formation of the cover or afterwards, forces greater than the resistance of the boom occur, the timbers submerge, and the ice passes over the boom. When these forces subside, the boom emerges and cuts off the ice flow. Thus, the boom provides a flexible resistance to ice passage that yields under excessive loads. It is, therefore, necessary only that the boom withstand the forces encountered during consolidation and retention of the ice cover under normal flow and weather conditions, and the forces applied during the occasional passage of ice over the boom. The St. Lawrence booms have been in service for eight winters, and have withstood a wide variety of conditions including high winds with ice riding over the boom. This experience is accepted as the best evidence of their adequate strength. The St. Lawrence booms are generally similar to the Niagara Boom which is described in detail subsequently.

The Niagara Ice Problem

Summary of Problem: At Niagara the ice problem is different than at the St. Lawrence, and has proven to be more difficult to solve. The Niagara River has always discharged large quantities of ice each winter, with reports of large ice runs dating back to when the area was first settled. In the river above the Falls, jams have occurred causing blockage, flooding and damage. In the Maid-of-the-Mist Pool below the Falls, an ice bridge usually forms and, in some years, massive accumulations of ice there have damaged bridges and power installations.

Following the 1950 Niagara River Treaty, redevelopment made Niagara a major power source for both Canada and the United States. The Power Authority of the State of New York and The Hydroelectric Power Commission on Ontario now have hydroelectric developments at Niagara totalling over 4,000,000 kW. The intakes for these plants are located in the Chippawa Grass Island Pool, a widening in the river just upstream from the Falls.

The intakes have a diversion capacity of over 175,000 cu.ft./sec. as compared to an average river flow of approximately 200,000 cu.ft./sec., the Treaty scheduling certain minimum flow over the Falls at all times. With these large intakes in operation and with the greater development also of the river itself, it became increasingly important that every effort be made to minimize ice blockages with their serious effect on power production and general damage to river installations. Since redevelopment of the river, an almost continuous program of river improvement has been carried out to facilitate the passage of ice, this program culminating in the construction of the Lake Erie-Niagara Ice Boom in 1964. The boom has operated successfully since that time, and it is now hoped that the ice problem is largely solved.

Nature of Ice Problem: Lake Erie with a surface area of nearly 10,000 square miles is completely ice covered each winter. The Niagara River, because of its relatively high velocities, normally remains open except in some areas in the Maid-of-the-Mist Pool and downstream where ice bridges or jams form. During cold periods of the winter, copious quantities of almost all types of ice; sheet, frazil, anchor, and slush, are formed in the open river, and grow in volume as they flow downstream. It is the ice from Lake Erie, however, that in the past caused the greatest difficulty. During the formation of the cover on Lake Erie, intermittent runs of lake ice would be frequently discharged into the river, and this ice would sometimes agglomerate into large masses. Normally, after the lake ice cover consolidated this, ice flow largely stopped as the ice formed a natural arch approximately 2 miles upstream from the river entrance, usually strong enough to prevent blockage. However, sometimes two or three times during a winter, because of the influence of heavy storms or seiches on the lake and accompanying level changes to 8 feet, this ice arch would be broken, releasing tremendous quantities of thick lake ice into the river. It was this ice, which would completely glut the river, that caused the greatest damage to river installations, and difficulty to power operation and massive jams on the Maid-of-the-Mist Pool.

Ice Control Measures: At the St. Lawrence, a stable ice cover over most of the headwaters was the solution to the ice problem. At Niagara this solution was not possible as the upper river is too shallow and too swift to permit the formation of such a cover, and excavation to produce a cover would be prohibitive. The action of Lake Erie during storms would provide most hazardous conditions even if a cover were possible. It is imperative therefore that ice which forms on the river and which flows into the river must be carried over the Falls and on into Lake Ontario, or a jam and flooding will develop.

The power intakes in the Grass Island Pool and the control dam at its outlet were all designed to facilitate ice passage. Continuous study of the problem has resulted in further improvements, e.g. ice escape channels, training walls, dredging to removal shoals, and the use of ice breakers. These facilities are now adequate for passing the normal ice formed in the river plus a moderate amount of Lake Erie ice. However, on occasion these facilities were not able to cope with massive runs of lake ice even with large reductions in power diversions. It was concluded that if an ice boom could be constructed at the outlet of Lake Erie to limit at least the massive discharges, then success in ice control probably could be achieved. In 1964 an ice boom some two miles in length was constructed across Lake Erie just upstream from the entrance to the Niagara River. The boom was a joint project of the Power Authority of the State of New York and The Hydroelectric Power Commission of Ontario, and was constructed after approval had been obtained from the International Joint Commission. This boom, which is similar to the St. Lawrence Booms, is described in some detail subsequently as it may prove to be of value in other ice applications.

Lake Erie-Niagara Ice Boom

Specific Function of Boom: It was not the intention that the boom by its own strength would hold back all the ice in Lake Erie. Rather, it was the intention to:

(1) provide a flexible structure to assist nature in quickly forming a consolidated ice cover over the eastern end of Lake Erie;

(2) reduce movement in the cover while it was being formed;

(3) provide additional stability to the downstream edge of the natural ice arch by minimising erosion and break off; and

(4) provide added resistance to breakage of the arch during storms.

The eastern end of the lake gradually narrows forming, in effect, a funnel as it enters the Niagara River. Once the solid cover has formed and becomes locked to the shore, the converging sides of the funnel prevent movement of ice into Niagara River providing the cover remains unbroken. Large water-level changes may break the shore restraint, but unless the cover is also sufficiently broken to destroy the arch action, the movement downstream will not be extensive. Rapid formation of a cover on the lake not only increases the strength of the arch, but also substantially reduces the effect of wind in causing water level changes, and by reducing wave action.

Site Selected: The location selected was based on a study of water velocities obtained from aerial photographs of ice runs, depths, shoreline configuration, relation to nearby physical features, and the downstream limits of the natural ice arch which normally occurs in this area during each winter. The location of this arch and its relation to the 1.5 ft./sec. contour is instructive. The selected boom location provides velocities generally not exceeding 1.5 ft./sec., good convergence of Canadian shoreline and Buffalo Harbor breakwaters, the shortest alignment available with these features, and is close to the natural arch location.

General Arrangement of Boom: The general features of the St. Lawrence booms were retained, but a number of modifications were suggested by experience at St. Lawrence and the realization that more severe wind and waves would occur at Niagara. The principal modifications were:

(1) larger diameter-anchor cables;

(2) larger floating timbers; and

(3) more flotation at the junction plates.

The steel cables spanning between anchor cables are 2 in. in diameter and 400 ft. long, and are galvanized 6 x 19 bridge ropes with a minimum breaking strength of 172 tons. At each end they are fastened by shackles to junction plates which are weldments with a thickness of 3 7/8 in. for boom cables and 5 3/3 in. for anchor cable shackles. Also fastened to the junction plates are anchor cables, spaced 400 ft. on centres across the river. These 28 anchor cables are 500 ft. long and 2½ in. in diameter and are galvanized bridge strands having a minimum breaking strength of 370 tons.

Each 500 ft. arc of horizontal boom segment is supported by 13 timbers each 30 ft. by 16 in. by 22 in. with a 6 ft. space between their adjacent ends. They are attached to the cable by two 7/8 in. chains each 4 ft. long, by means of chain shackles and cable clamps. The chain shackles were connected to 1½ in. U-bolts located 3 ft. from each end of the timber. Two 1 in. diameter bolts were installed 2 ft. from each end of the timbers at right angles to the U-bolts to control end splitting. The timbers constitute the resistance to ice movement, and support the cable which remains approximately 4 ft. below water level.

At each junction plate, the buoyancy of the boom was increased by providing one large buoy tank and two smaller tanks. The larger tanks were 3 ft. 6 in. in diameter by 5 or 6 ft. long. One such tank was attached to each junction plate. A tank 2 ft. in diameter and 3 ft. long was connected to the cable 6 ft. from the junction plate on one side, and 12 ft. on the other. The tanks served to reduce the tendency of timbers near the junction to be drawn under or "broom".

Each anchor was constructed by drilling a 30 in. diameter hole approximately 20 ft. into bed rock. Double anchors were provided at key locations so that 28 anchors were used for the 22 boom segments.

Boom Strength: Experience at St.Lawrence indicates that it is not possible to predict with accuracy the forces which will be sustained by the boom before the vertical components of anchor-cable tension causes the boom to submerge. However, it is a simple matter to calculate the ratio of forces in the various components of the boom. Such calculations require only an assumed distribution of forces along each boom segment. It was recognised that failure of one boom segment would open a 400 ft. wide gap. In contrast, failure of an anchor could result in overloading adjacent anchors, and might thus produce successive anchor failure. With this in mind the strength of the horizontal boom-segment cables was selected so that it would break before the anchor cable or anchors. The load resistance ratios of boom cables, anchor cables and anchors are 1.0, 2.0 and 2.4 respectively.

Boom Anchorage: At the St. Lawrence the river bed was not rock, but glacial till of various densities. Two types of anchors were used there; one for relatively hard bottom, and one for a relatively soft bottom. These anchors were developed originally by the Quebec Hydroelectric Commission. At Niagara, as the lake bed was rock overlain with shallow overburden, steel posts were grouted into 30 in. holes drilled approximately 20 ft. in the lake bed.

Experience with Boom in Action: Based on nearly three years of operation, the performance of the boom to date is considered to be an unqualified success. Whereas each winter is different and many years may be required to obtain a complete assessment, so far at least, the boom has fulfilled its function effectively.

During the three winters of operation, conditions were experienced which in pre-boom times undoubtedly would have produced heavy runs of ice, both during formation of the cover and after consolidation. During formation of the covers, only minor runs came over the boom even during periods of high winds and no reduction in power production was caused. There was no mid-winter breakup of lake ice which produced prolonged ice runs after consolidation and no damaging discharges of ice down the river.

CCMS No. 2

PROGRAM GUIDE TO AGREEMENT COVERING A PLAN FOR FLOOD CONTROL IN THE LOWER FRASER VALLEY, BRITISH COLUMBIA

(Presentation by Canada)

Introduction

The Fraser River has played a vital rôle in the development of British Columbia since the days of the early fur traders of this nation. It provided the waterways so essential during the gold rushes of the last century and the development of the pioneer timber industries. Its valleys provided the transportation routes which cut through the mountains to link this most westerly province to Canada during the early days of confederation.

Fed by the melting snows from the mountains the silt-laden flood waters of the Fraser River have through the years developed a fertile flood plain and delta at the mouth of the river system. This area, stretching some 80 miles inland from the Pacific Coast, now contains a very considerable percentage of the province's population, industry and prime agricultural land and the floods which formed this valuable land now represent a menace to the economy of the area.

This flood threat has resulted in the development of an extensive dyking system in the Lower Fraser Valley, however the increasing development in the valley and the continuing threat of floods, even more disastrous than those experienced in the past, have prompted the federal and provincial governments to agree on a program of better flood control and drainage works for the area. This Program Guide sets forth the background and objectives of that agreement.

Background

In the summer of 1948 the Fraser River breached the protective dykes of the Lower Fraser Valley, inundated some 55,000 acres of land, destroyed or damaged over 2,000 homes and virtually severed the southwestern corner of the British Columbia mainland from the rest of Canada. The damages and losses in the area were estimated as $17.5 million.

Late in that same year the provincial and federal governments established the "Dominion-Provincial Board, Fraser River Basin" to study and report on the water resources and requirements in the Fraser River watershed. That Board acted largely as an investigatory body gathering the basic data missing from the then existing records. In 1955 the Board was replaced by the Fraser River Board which was given specific terms of reference calling for the determination of "what development and control of water and incidental resources of the Fraser River basin would be adivsable and feasible, particularly with respect to flood control and hydroelectric power".

In 1963 the Fraser River Board presented its final report which recommended construction of five upstream power and storage reservoirs, three hydroelectric power plants and one power and diversion project at a total estimated cost of almost $400 million. They also recommended $4.9 million worth of improvements to existing dykes along the Lower Fraser from Agassiz to the Strait of Georgia to supplement the protection provided by the upstream reservoirs.

No immediate action was taken on the Board's report and in 1966 a federal-provincial committee was established to review the Board's estimate of expenditures required for dyking improvements along the river. In addition to this the Committee was to consider other requirements such as sea dykes, improved drainage and pumping capacity and protection against erosion.

The federal-provincial committee reported on a plan of protection involving the expenditure of approximately $33 million. On the basis of this report, and the continuing awareness and concern over the ever-increasing need for flood protection, the two governments in May of 1968 agreed to a co-operative program of works in the Lower Fraser Valley and a review of the upstream storage projects necessary to provide a comprehensive plan of protection.

The Program

The program being embarked upon by the governments of Canada and British Columbia has as its ultimate objective a comprehensive plan of flood control and protection for an area which is vital not only to the economy of the province itself, but also to the nation as a whole.

Over half of the population of British Columbia lives in the lower Fraser Valley and much of the industrial development and agriculture of the province is concentrated in that area. At the same time the valley of the Fraser continues as it did in the early years of this nation to serve as the principal transportation route to the Pacific Coast. Both national railway systems and the trans-Canada highway follow the Fraser River system for several hundreds of miles to Canada's major Pacific Coast outlet at Vancouver. In the Lower Fraser Valley these transportation arteries traverse the old flood plains of the river where they and the major export-import industries which they serve are susceptible to extensive loss and damage from extreme flooding. As was the case in 1948, but even more pronounced under present day conditions, the potential loss to the Canadian economy through the flooding of these routes would be extremely high.

In view of this combined federal-provincial interest in adequate flood protection the two governments have agreed to share equally the major portion of the cost of flood control works carried out under the development program. The municipalities benefiting from the works will be asked to pay an equitable portion of those costs.

The program will concentrate on the following aspects of flood protection:

River Dykes: Over 200 miles of dykes already exist in the Lower Fraser Valley area. These facilities, assisted by limited flood control operation of upstream power developments, constitute the works which presently protect some 160,000 acres of land in this area.

Many of the existing dykes were either repaired or reconstructed following the severe damage caused by the 1948 flood. However, while they were able to withstand a second but less severe flood in 1950, recent tests have indicated that they only protect against flood levels appreciably below the desired design elevation.

The present federal-provincial program will either reconstruct or replace these dykes and will also provide for the construction of dykes in areas which are not now protected. Dykes around Indian Reserves will also be either constructed or repaired. Altogether 222 miles of river dyking will be covered by the program.

Sea Dykes: Sea dykes presently exist around areas of Lulu Island, Sea Island, Westham Island, and the mainland portion of the Municipality of Delta. These dykes also require reconstruction to provide adequate protection against flooding which is caused by high tides or by a combination of tides and high river flow. It has proved virtually impossible to distinguish between the respective contributions of these two causes.

Pumping and Ditching: In addition to protection against flood flows by dykes a program of better internal drainage is required to prevent damages to the lands enclosed by the dykes. The construction of dykes obstructs the natural drainage of lands and a system of ditches and pumps becomes necessary. Some of the pumping installations which now exist require rehabilitation; however, even with this rehabilitation, the capacity would not be adequate to remove the runoff caused by winter storms. Additional pumping capacity and main drains, as distinguished from local or farm drainage, are required to prevent water-logging of lowland grass and crops.

Bank Protection: In addition to direct and indirect damage caused by flooding, there is a considerable mileage of river bank in the Lower Fraser Valley which is threatened by erosion. Some of the banks have been stabilized by the application of quarried rock while other sections have been given no protection. The river channel is largely unstable by nature and future erosion points are unpredictable, but where erosion is obvious at present some bank stabilization measures would be beneficial and are contemplated by the joint program.

Tributary and Contiguous Areas: Although not considered in the 1963 report of the Fraser River Board there are several areas subject to flooding on lower tributaries of the Fraser system, for example, the Coquitlam and Vedder Rivers, and on the adjacent river systems of the Serpentine and Nicomekl.

On the southward flowing Coquitlam River flooding and bank erosion have caused damage to roads, bridges, buildings and homes. Dyking and channel improvement works could protect against this in future. Similarly, the Vedder River to the southwest of Chilliwack has a four-mile section of erratic stream bed in a developed area. A heavy runoff could threaten this region if the stream channel shifted to a new position. Dyking, and river training works could protect against this possibility.

The Nicomekl and Serpentine Rivers lie in the flat flood plain to the south of the Lower Fraser River and discharge into the sea at Boundary Bay. While dykes exist on these river reaches they are in need of reconstruction. In addition, new pumping and drainage facilities could provide increased production from some 16,000 acres of farm land by lowering the water table to acceptable levels.

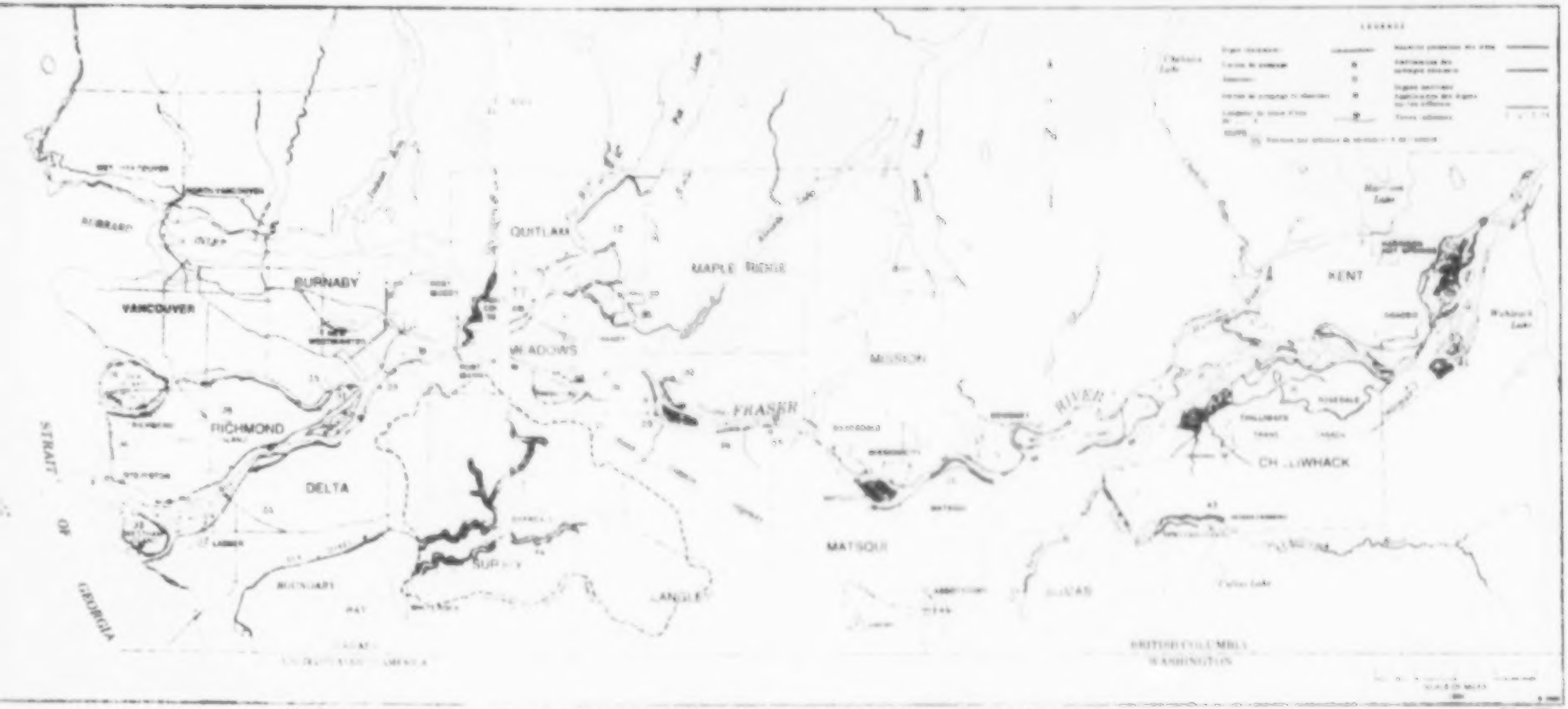
Flood Plain Zoning and Flood Proofing: In addition to the joint works referred to in the preceding sections, the Agreement entered into by Canada and British Columbia envisages that the Province will encourage a program of zoning lands in the flood hazard area. Unrestricted development in either protected or unprotected areas adds very significantly to the damages and losses experienced when flooding does occur. Such a zoning program can be a significant contribution to the overall flood control plan.

A practice which has proven effective in unprotected lands or lands with a minimum of protection has been the flood proofing of buildings on those areas. Where flooding to shallow depths is experienced, the raising of barn or home foundations or construction on raised earth mounds and other such measures can effectively reduce the damages which would otherwise be experienced. Under this agreed program the Province will also encourage such measures in areas where they would prove effective.

Evaluation of Upstream Storage: In its 1963 report to governments the Fraser River Board recommended the development of a system of upstream storage reservoirs be proceeded with to "... ensure greater safety to the settlements along the river system". The reservoirs recommended by the Board were selected so that the necessary degree of protection could be provided and yet the development would be compatible with the maintenance of salmon runs of the Fraser system. The Agreement now entered into by the governments of Canada and British Columbia calls for a joint review of the 1963 report and undertaking such other studies as may be pertinent with a view to assessing the significance of possible upstream developments, including storage of water, to give added insurance against future flood disaster.

Implementation

The Agreement which the two governments have entered into have a termination date of 31st March, 1978. During the next ten years the program outlined by the Agreement and this Program Guide will be advanced by two joint federal-provincial bodies; the Joint Advisory Board and the Joint Program Committee. These bodies will be responsible for the overall implementation of the program in order to maximize the protection and benefits to be derived from the control of the waters of the Fraser River. Recommendations for construction of specific works will originate from the Board and the Committee following a full review of soundness of the projects from an engineering viewpoint as well as their economic justification in the light of both the direct and indirect benefits which will be realized by the Province and by Canada as a whole from full implementation of this program.


NORTH VANCOUVER
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LANGLEY
FRASER
RIVER
MISSION
MATSQUI
SUMAS
CHILLIWACK
KENT
STRAIT OF GEORGIA
BRITISH COLUMBIA
WASHINGTON

MAP OF LOWER FRASER VALLEY SHOWING PROPOSED FLOOD CONTROL WORKS

PLATE 1

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FLOOD DAMAGE REDUCTION IN CANADA

Ian Burton

ABSTRACT

In more than 200 communities floods are a constant threat to life and property. From time to time major disasters occur as in Vancouver (1948), Winnipeg (1950) and Toronto (1954). It is difficult to assess the national picture due to lack of data on flood damages. The experience of the United States and Britain suggests that flood damages may be increasing.

Four case studies (Belleville and Toronto in Ontario, Calgary and Red Deer in Alberta) are examined to show the varying types of flood problems and the ways in which they are being solved.

The report concludes that there is need for a broader attack on flood-loss reduction including flood-plain zoning, urban renewal and flood proofing as well as conventional engineering approaches. There is also need for the collection of flood-damage data and for the dissemination of information on flood hazards to planners and private citizens.

(The complete text of the presentation can be found in Geographical Bulletin Vol. 7, Nos. 3 and 4, pp. 161-185, 1965).

AIRPHOTO INTERPRETATION AS AN AID IN FLOOD SUSCEPTIBILITY DETERMINATION

> "..... along most rivers there seems to be a general relationship between frequency of flooding and certain alluvial features of the valley bottoms .... The relation of terrain to floods as an aspect of human geography has hardly been studied, at least not nearly so extensively as river hydraulics and hydrology."

by L.C.N. Burgess, Canada

Introduction and Background

The recent flooding in northern Italy has perhaps received wider publicity than any flood in recent history, because of the damaged art treasures at Florence, and the great strain that has been placed upon the Italian economy by the magnitude of the general flood losses. However, few floods receive anything like this amount of publicity. Generally, the news media seem to report damaging floods more in terms of the number of persons drowned and families driven from their homes than in terms of the dollar value of damages incurred. It is also true that many floods do not merit world-wide or even national news coverage, even though to-day's sophisticated news media are fully capable of providing it. Even in the personal experience of residents of our many flood plains, flooding may be a relatively rare occurrence, for these disasters are unevenly distributed over time and directly affect only a small fraction of the total population. Furthermore, man has a propensity for forgetting the unpleasant. These factors would seem to be the main reasons for the insufficient awareness on the part of the public of the enormous damage caused by floods.

The gravity and chronic nature of flood problems may in large measure be appreciated, when one considers that in the United States, the country for which most complete figures are available, $4,000,000,000 was spent on flood control measures from 1936 to 1957. However, in spite of this expenditure, average annual flood damages continued on an upward trend which began about the turn of the century. This increasing average annual damage is accounted for in large part by continued encroachment of development upon the flood plains. Flood-plain development will, however, continue to take place regardless of whether absolute flood damages increase or decrease because this land form still has many obvious advantages for agriculture, transportation and urban development. There are several noteworthy examples of continuing flood-plain encroachment in Canada, one of which is the Lower Fraser River Valley. Here in 1948, one of the most extensive and certainly the most costly flood in the river's recent history occurred. Despite this disastrous flood, during the subsequent 1951-1961 census period, the population growth rate on the flood plain was double that of the valley as a whole, while the rate for the metropolitan Vancouver portion of the flood plain was almost four times as fast as for the rural area.

Proponents of flood-plain zoning acknowledge the inevitability of further encroachment on flood plains and the impossibility of providing complete flood protection by structural measures. Indiscriminate flood-plain development is wasteful because unnecessary flood damage occurs sooner or later. Complete prevention of flood-plain use is equally wasteful since the flood plain's distinct advantages for development are neddlessly forfeited. The need for compromise between these extreme positions has been recognized by advocates of flood-plain zoning. Even zoning is but one of many alternative adjustments to floods, among which must be found the optimum compromise. Ideally, zoning should occupy the pivotal position in this group of flood adjustments in order to minimize costs and maximize benefits.

There are three main reasons why flood-plain zoning has not been accepted more widely and rapidly in the three decades since it was first introduced:

(1) unwarranted faith in the ability of engineering structures to control floods;

(2) aversion to restrictive laws, and

(3) lack of a composite picture of the flood-plain environment upon which to base zoning regulations, particularly lack of flood susceptibility information.

The purpose of this paper is to discuss a new method, namely airphoto analysis and interpretation, which can aid in eliminating this third obstacle.

But before going on to discuss the rôle of airphoto analysis and interpretation, it is desirable at this stage to digress briefly in order to show why comprehensive pictures of flood-plain conditions are not available. When zoning was first introduced, flood-plain information was only available as rather isolated facts such as stream gauge data that were difficult to interpret for planning purposes. It was not until the 1950s that in Canada and the United States a more composite picture of flood-plain conditions during flooding, was incorporated in reports that could be used by planners, thereby partially fulfilling a long standing need.

These reports dating from the 1950s fall into three general categories:

(1) comprehensive watershed planning reports;

(2) flood control planning reports; and

(3) flood hazard mapping reports.

Although three different purposes lie behind the preparation of these reports as indicated by the titles, from the point of view of their usefulness to the prospective flood-plain zoner, they are remarkably similar in content.

Hydrologic data, historical records and field interviews provide the main basis for the flood-plain investigations which constitute all or a portion of these reports. Supplemental information on the major floods cited in these reports is sometimes obtained from specially flown flood or post-flood photography. However, unfavourable weather conditions or delay in arranging contacts, often prevents acquisition of this photography. Flood photography is unexcelled in depicting the outline of flood water at a particular point in time and is valuable in helping interpret pre-flood photography. Such flood photography, when obtainable, is also of great value to the hydrologist for the purpose of checking stage-discharge and stage-inundation relationships, but is less valuable to the regional or city planner because much of the flood plain is obscured by water during and after these relatively rare events.

Although such conventional flood-plain studies provide information on extent, frequency and depth of flooding, they neglect to include important aspects of the flooding phenomenon, aspects which are necessary for more rational flood-plain use or regulation. The reports commonly include maps showing the area inundated by one or two major historical floods, as well as the area expected to be covered by the "design" or maximum probable flood. Stream profiles indicate the water depth at various stations for both historical and probable floods. Dramatic newspaper photos, either ground level or aerial obliques, serve to emphasize the hazards of flood-plain occupancy even more than eyewitness accounts of specific floods. In sum, whereas hydrologists and flood control planners have, in presenting these flood-plain studies, considerably improved our knowledge and understanding of the frequency distribution of flooding of various depths and extent, little has been done to place these vital studies in an all-embracing framework. These more conventional studies have tended to emphasize flooding per se, but have neglected to specify the characteristic features of floods and flood plains which are crucially important for would be users of flood plains. This apparent lack of emphasis on interpretation of data for the use of planners, stems, I should imagine, partly from public pressure for flood damage prevention and also public apathy, heretofore, toward rational land use planning.

The foregoing pin-points the need for a more integrative approach to the study of flooding. A young but extremely promising discipline which can be and is being used to integrate the work of both hydrologist and planner is Air Photo Analysis and Interpretation which attempts among other things to comprehend the problem in its entirety.

In the industralized countries, for instance, interpretation of aerial photographs taken under non-flood conditions can supplement flood-plain studies and watershed planning with information that is useful to the hydrologist and invaluable to the planner. The hydrologist concerned with minimizing damage from watershed runoff must pay heed to more than stage-discharge and stage-inundation relationships. For example, constrictions in the stream channel and the location of natural floodways each warrant his attention, and are given his consideration, but are not usually discussed in reports in such a manner that their full implications become apparent to those engaged in flood-plain regulation, use or development. On the other hand, there is apparently little awareness on the part of hydrologists, of the presence or importance of such terrain features as slack-water areas, in which flood water will be ponded for extended periods of time, nor of scoured areas, in which the highest overflow current velocities may be expected. Such information may be of limited use to the hydrologist, but it is essential for evaluation of the potentials and hazards of flood-plain occupancy - a vital element in rational flood-plain planning and development.

In the developing countries airphoto interpretation can be effectively used as a substitute for the more sophisticated and costly flood-plain studies alluded to above. Meaningful and detailed hydrologic studies require engineering expertise and a backlog of long-term hydrologic data. As will be described below, airphotos capture the effects of long-term stream flow and flooding. Furthermore, the information gained from the photos, will have potential for broader application than the more specialized but unobtainable hydrologic information.

What is airphoto interpretation?

Airphoto interpretation consists of three increasingly sophisticated levels of procuring information from aerial photographs. Photo reading, the simplest level, is the identification of physical and cultural features and the determination of their spatial relationships. Stereo viewing is helpful but not essential for this for this data-gathering procedure. Photo analysis, the intermediate level, includes the procedures of photo reading but goes further to allow analysis of the arrangements and physical characteristics of photo features. This analyais provides a basis for the classification of residential areas, soils, land use, and so forth. Stereo viewing is usually essential for this approach. The most advanced level, photo interpretation, goes on from a background of photo reading and analysis to "explain the meaning of information obtained from airphoto study in terms of some particular objective". It may also be thought of as the technique of obtaining information of an inferential nature not directly visible on the photograph. Stereo viewing is essential to this approach, which depends for success upon the relevance of the interpreter's experience and training to his particular objective.

Airphoto interpretation is an effective method of obtaining unique flood susceptibility information. We will address ourselves to the perceptive interpretation of aerial photography, which has already been acquired at considerable expense for other purposes in nearly all countries. Though up-to-date information is lacking, one-half the land area of the world had been photographed at least once by 1959. Most of the more developed countries have been covered by photography completely one or more times. So much new photography is obtained each year that it is now probably safe to say that even in the least advanced countries, practically any area of interest to a water resource administrator or specialist has photographic coverage. Since much of the world's aerial photography has been obtained by military agencies and aerial survey firms located in Canada, the United States, Great Britain and France, much of the information on overseas coverage is available through sources located in these countries, and not always in the country photographed. A national, seeking information in his own country on photo coverage, should direct his inquiries to those government departments which are concerned with Defence, Resources, and Development. Finally, in regard to the acquisition of aerial photography, it is worthwhile making a comment on the costs likely to be involved. The cost of 1:20,000 scale contact prints can range from a few cents to a few dollars per square mile of stereo-coverage. On the other hand, new photography will cost from a few dollars to a few tens of dollars per square mile. The economic advantage of utilizing available photography need scarcely be emphasized.

Airphoto evidence of major floods

The large volumes of water involved in major floods and the resultant high velocity currents, ensure that these rarer floods leave conspicuous evidence of their impact. Property damage of one sort or another is usually the first to catch the eye of the ground observer, and because of the clarity of this evidence it is usually the first to be eliminated, primarily through repair and cleaning-up operations. But even if vertical photos are taken immediately after a flood they are unlikely to record the full extent of the damage unless they are supported by aerial obliques. Major floods may also leave new or accentuated flood evidence in the form of modifications of the natural landscape. These modifications may be as dramatic and significant as a newly cut channel section, though, even in the case of a major flood, are more likely to be confined to more subtle alterations of existing features such as sand splays or scour marks. Although on the ground this "natural" evidence of severe flooding is usually less obvious than property damage, from the air it stands out distinctly. Light greyish or brownish sand splays which may be nearly concealed from view in a weedy vacant lot appear as dazzling white on post-flood photography. Deepened scour marks will stand apart from portions of abandoned channels, a distinction less easily made on the ground. The existing features which may be highlighted following severe flooding, are in most cases features that result from the effect of more frequent but less extensive overflows.

Airphoto evidence of minor floods

Minor and more frequent floods differ from major floods more in degree than kind, at least as far as direct evidence upon the flood plain is concerned. These more frequently occurring floods cover a smaller portion of the flood plain, and the frequency-inundation relationship, which is so familiar to hydrologists, provides the basis for separating frequently and infrequently flooded areas. Minor floods do not erode, deposit or damage as extensively or severely as major floods. However, the relatively short time interval between minor floods means that this direct evidence may remain almost unmodified through natural processes or man's activities during the interflood periods. The frequent intensification of this flood evidence in susceptible areas may be more subdued through modification over a longer interflood time period.

Frequently flooded areas are also characterized by the closer adjustments of man's activities to flood-plain conditions. Indirect evidence of this type, subtle though some of it may be, is just as useful as that direct evidence which is left behind after a particular flood. Compensating for the sublety of the indicators is the degree of sensitivity expressed by adjustment of life to flood susceptibility. Flood-plain farmers, probably because they live "close to the land" often demonstrate a keen awareness of flood-plain conditions and a discrete response to them that their urban counterparts almost completely lack. By way of contrast, in urban centers where physical structures tend to obstruct a comprehensive view of the physical geography of the area, and where residents are forever on the move, it is small wonder that some residents can live within a stone's throw of a channel and be unaware of its significance. There seem to be more maladjustments to the flood plain in the urban than in the rural environment. Whereas in the rural situation maladjustment to flood-plain conditions often relfects misguided gambling with nature, in the urban situation maladjustment more often reflects decisions made in ignorance. It is important to recognize flood-plain maladjustments during airphoto interpretation which otherwise could result in erroneous flood susceptibility evaluation. Ways of avoiding this error are discussed subsequently.

The type and distribution of vegetation is a sensitive indicator or soil and moisture conditions which in turn reflect flood susceptibility. The relationship of vegetation distribution and crop condition to flood-plain conditions seems closest in the generally more flood-prone areas, because here soil conditions change most rapidly. Just as existing flood-induced physical features on the most susceptible portions of flood plains are accentuated by the more extensive major floods, so the adjustment of vegetation in these areas is likewise sharpened.

It is necessary to emphasize here that since major floods occur infrequently, and since any aerial photo records the cumulative impact of all preceding floods, most photographs whether taken before or after a major flood, will no doubt reflect approximately the same evidence with perhaps varying degrees of clarity. Thus, it would appear uneconomical to acquire "post-major flood" photography unless all existing photography fails to provide certain requisite information, because the disproportionate high cost of these photos is unlikely to be offset by the additional information.

Flood susceptibility determination

Direct and indirect evidence of flooding takes many forms, only a few of which have been mentioned in the preceding section. In providing an unbiased cumulative record incorporating all this evidence, the airphoto facilitates its compilation and analysis for the determination of relative susceptibility of an area to flooding. The value of this flood susceptibility information is superior in some respects to that which is or could be accumulated by ground methods alone, because it derives from a critical four dimensional examination of the total flood-plain environment. The photo background from which the information is gleaned, is at one and the same time a three dimensional panoramic and detailed view of the flood plain, while time, the important fourth dimension is captured in the stream's geomorphic history and man's adaptations, as already noted.

In Canada, which was one of the first countries to obtain substantial airphoto coverage for peaceful purposes, sequential photography covers a span of more than four decades. The repetitive aspect of this coverage adds a time dimension of a different nature. Old photography which has captured the scene at intervals over the past few decades, has added value such as, permitting study of natural flood plain features long since obliterated by urbanization, or facilitating land use change studies.

A complicating factor encountered in attempting to determine relative frequency of flooding is the wide variation in absolute flood frequency on different streams. Although recognized authorities have stated that a 1.5 year frequency of "bank full" stage seems a good average, little affected by physiographic setting or stream size, our perusal of many watershed planning reports indicates that in a substantial number of watersheds being treated for flood control, the streams flood up to 10 or 15 times per year. This apparent contradiction is accounted for in large part by their definition of "bank full". Since it is defined as the difference in elevation between the stream channel profile and the flood-plain profile, both being average lines drawn through a number of points, it follows that many points along the bank will be topped by flood water before the "average bank full" stage is reached. Many factors account for this very wide variation in absolute flood frequency, but this frequency should be recognized and taken into account in the determination of the relative susceptibility to flooding of different portions of flood plains.

For this and other reasons that are covered subsequently, no attempt is made to present a formal key for flood susceptibility classification. Rather, those indicators, visible or inferable from airphotos, which bear a positive or negative relationship to flood susceptibility, or which are otherwise useful in estimating susceptibility are grouped in Table 1 under six indicator classes:

(1) Meteorologic.
(2) Physiographic.
(3) Geomorphic.
(4) Topographic.
(5) Pedologic.
(6) Socio-Economic.

Some indicators have undoubtedly been omitted from this table, but it is believed the most relevant are included. The value of the indicators is not only for determining relative susceptibility of an area to flooding, but for determining other flood characteristics such as potential hazard from erosion, sedimentation and extremes in floodwater velocity as well as relative duration, depth and areal extent of inundation. In fact, in many instances it is easier to ascertain characteristics of flooding or the susceptibility to certain types of flood hazards, than it is to determine relative flood frequency.

The characteristics of flooding are determined in the main by meteorologic and physiographic factors, thus, the meteorologic and physiographic classes are composed mainly of causative flood factors. On the other hand the geomorphic, topographic, pedologic and socio-economic indicators in large part result from flood characteristics and hence are derivative in nature. These six classes of indicators should also serve to guide the utilization of any available meteorologic, geologic, soil or economic reports for susceptibility determination. Information in such reports may serve to strengthen conclusions drawn from the airphotos.

In the following treatment, selected indicators will be discussed to illustrate their value for flood character determination and to show their interdependence. Some consideration is given to the relative significance and dependability of the different lines of evidence, both in terms of inherent reliability and in terms of variability that results from characteristics of the photography.

Meteorologic indicators

Much of the meteorologic information of the type listed in the table will come from reports or be common knowledge, but this information has unequalled relevance to flooding and must be considered for accurate photo interpretation, whether it is derived from the photo or a report. For obvious reasons these indicators lend themselves to evaluation through airphoto interpretation less than those of any other class. However, when one considers the scarcity of meteorologic information which exists in many areas, even in the industrialized countries, the value of airphotos in obtaining and utilizing meteorologic information can be better appreciated. Commonly rainfall data are only available for a municipality in the lower reaches of a watershed. The distribution of rainfall in the watershed due to storm direction and the

TABLE 1

FLOOD SUSCEPTIBILITY INDICATORS

Class I - Meteorologic

Climate

- Seasonality
- Temperature
- Precipitation
  - Distribution
  - Intensity

Storm Type

Storm Direction

Orographic Effect

Class II - Physiographic

Bedrock Composition

Bedrock Structure

Upland Physiography

Watershed Shape

Valley Orientation

Flood-Plain Shape

Proportion of Watershed in Flood Plain

Stream Drainage Pattern and Density

Discharge to

- Next Order Stream
- Much Larger Stream
- Lake
- Tidewater

Underfit Streams

Class III - Geomorphic

Flood-Plain Type

- Meander Plain
- Cover Plain
- Bar Plain

Alluvial Fans

Terraces

Levees

- Active
- Abandoned

Point Bars and Swales

River Bars

Deltas

Channel Configuration

Channels

- Abandoned
- Oxbows
- Filled

Backswamp Areas

Marshes

Former Lake Beds

Dunes

Landslides

Springs and Seeps

Depth to Water Table

Swamping

Valley Trenching

TABLE 1 (Contd)

FLOOD SUSCEPTIBILITY INDICATORS

Class IV - Topographic

Relative Elevation

Slope

Slope Changes

Slope Complexity

Micro-relief

Class V - Pedologic

Structure

Texture

Organic

Salinity

Depth

Vertical Uniformity

Permeability

Drainage

Erosion

- Type
- Extent
- Severity

Deposition

- Type
- Distribution
- Freshness

Class VI - Socio-Economic

Land Use (Rural and Urban)

- Character
- Intensity
- Changes over Time
- Boundaries
- Alternatives
- Limitations

Building

- Type
- Location
- Condition

Transportation

- Type
- Location
- Condition

Flood Alleviation Measures

Channel Constrictions

Repair Work

Farm Characteristics

- Size
- Type
- Location
- Management Practices
- Crop Condition

Vegetation Removal

- Logging
- Land Clearing

Revegetation

orographic effect can be determined on airphotos, at least in relative terms, from consideration of the topography and vegetation distribution. These and other considerations can lead to the determination of the relative amounts of runoff from different tributaries. This alone allows prediction of higher flood stages on the mainstem reaches below these tributaries. Small-scale photography which provides the more all-inclusive view might be helpful for such meteorologic studies.

Seasonality in rainfall distribution that indicates when floods may be expected, takes on added significance when airphoto interpretation reveals the seasonal development of sand bars or spits at river outlets, which may restrict flow with the return of the rainy season. Winter temperatures which are extreme enough to allow ice to form on rivers are common in many countries in the high latitudes. The very long northward flowing rivers common to Canada and the Soviet Union are particularly prone to this complicating flood factor. The extent of inundation which is forecast on the basis of standard hydrologic procedures becomes an unreliable guide, under those conditions where ice jams form. On streams where ice jamming is a common event, careful airphoto study may reveal diagnostic clues. Alternatively, it may be possible to draw inferences about ice jam frequency and probable location from apparently unrelated evidence. A classical example of such airphoto interpretation "detective" work was in the case where "grooves in lake bed sediments made by (wind blown) pan ice were related to shallow water of the (post-Ice Age) lakes, and thus to more salty soils". The frozen condition of flood plains during spring runoff floods accounts for the anomalous indistinctness of scour marks on flood plains characterized by this seasonality of flooding. Deposition from such spring floods is not so greatly diminished because the channel acts as a source of sediment.

Physiographic indicators

The gross physiographic characteristics of a watershed are indicative of the nature and frequency of flooding. The bedrock structure of an area has a profound influence upon the shape of watersheds, while the bedrock composition closely controls the drainage density and pattern. Nearly circular watersheds for example may develop in structural basins. Other factors being equal, frequent flooding is indicated for watersheds which tend to be circular and characterized by mountainous uplands and a dense drainage network. Some watersheds of this nature which are known to flood frequently over very broad flood plains shows surprisingly little in the way of flood-plain scour and sediment damage. In these cases, however, it is in accord with flood-water ponding which results from constriction of the flood plain down stream or results from backwater effects where streams empty to tidewater. This observation also illustrates the point that there is a close relationship between the larger features of the watershed and the smaller features of the flood plain. Flooding of this nature also may occur in limestone terrain, because limestone solution which has resulted in the development of a discontinuous surface drainage system, has not yet advanced far enough to carry storm runoff into the underground without prolonged surface ponding.

In any area where a stream empties into another, there may be the problem of the common flood plain, however, it may be quite evident from the pattern of flood deposition on photographs which stream dominates the flood problem. Also the diminution of certain kinds of flood evidence in the lowest reach of a stream may indicate frequent flooding and backwater from the one into which it empties. For the purpose of assigning damage costs and benefits it is important that the problem of common flooding be accurately resolved.

In this brief discussion, the physiography of a watershed has been shown to be relevant to flood susceptibility, erosion and sediment damage, flood-water velocity, and duration and extent of flooding. As in the case of meteorologic indicators, the photo characteristic of most significance is probably scale, since small-scale photography facilities appraisal of gross watershed characteristics.

Geomorphic indicators

The numerous land forms and landscape features cited as geomorphic indicators are more easily grouped to designate expected flood characteristics than relative flood frequency. The reason lies in the fact that flood-plain features are quite well understood in terms of processes involved, texture, depositing water velocities and duration of inundation. But little has been written on the relation of these flood-plain features to frequency of flooding. Geologists recognize that meander plains built primarily through lateral channel migration and resultant point bar deposits, flood less frequently than cover plains which are blanketed by vertical accretion deposits. However, they have not gone much beyond this gross generalization.

The comparative elevation of different flood-plain or terrace levels clearly shows relative potential for flooding, but it is their subtle surface features which tell whether or not they are still subject to flooding. Terraces exhibit the same surface features as lower portions of the flood plains. Some of these features of course may be relicts from the time when a terrace was a more active flood-plain bottom, but others are present day features whose distinctness reflects the frequency of flooding. Especially on higher terraces, these clues may be so subtle as to be indistinguishable except from the air. Tonal and vegetational changes may be the most obvious expression of levee and slack-water deposits on a terrace.

Alluvial fans present flood problems that are peculiar to them alone, because of their relatively steep gradient and the transitory and branching nature of their multiple channels. Flood-water velocities, sediment load and texture are reflected in the channel configuration, cross-section shape and character of scour marks, which are most easily assessed on airphotos. Sequential photography records channel location changes which help predict new channel courses and areas of increasing flood hazard.

Along the larger streams, natural levees may provide almost the only land suitable for intensive development. Abandoned levees are less susceptible to over-topping than active ones, as indicated by the less distinct scour marks running down their back slopes. The soils on abandoned levees will be more mature and of higher productivity than texturally comparable soils on active levees, making them more attractive for agriculture. Much soil information of this nature can be obtained by airphoto interpretation. On abandoned levees, flood proofing specifications for buildings could be adjusted to take account of the diminished hazard from high velocity currents and intense scour and sedimentation which characterize flooding on active levees. The activity of a channel and consequently the degree of abandonment of levee, can perhaps be better determined from examination of these features in the context of the whole flood plain on airphotos than any other way. Slack-water areas behind active levees may be more susceptible to flooding than the levees themselves, because water may move down the flood plain behind the levee before it is topped. Areas where the bank full stage is first reached are readily located by the large scour marks which identify them. If the soil at the time of photography is either too dry or too wet, or the flood plain is heavily vegetated, then less use can be made of soil tone changes in the recognition of scour marks, and more reliance must be placed upon vegetative and topographic clues to overbank flow. The configuration of the main channel will also indicate where overflow can be expected when other clues are weak.

A particularly easy guide to flood susceptibility is the presence of stabilized or vegetated sand dunes on river terraces. The persistence of these land forms in a stabilized condition is precluded by flooding, therefore their presence indicates non-susceptible areas. But certain other factors relevant to land development are then apparent. Special treatment of dune sand is required for road subgrades and severe wind erosion may follow soil disturbance resulting from other development. In the case of dune plains traversed by relatively small streams, the dunes may modify channel configuration and contribute substantially to flood hazard by decreasing its capacity.

Heavy rainfall on saturated ground which forebodes maximum flood hazard, also sets the stage for landslides in areas where soils are susceptible to this phenomenon. Particularly in areas of residual soils this hazard not only coincides in time and space with the flood hazard, but increases it, especially by contributing vast amounts of sediment and vegetative debris to flood waters. This was the case in the December 1964 floods in the US Pacific Northwest. The value of airphotos for locating these hazard areas is well established.

To optimize results from the interpretation of geomorphic indicators, photography should be large-scale, and taken when the soil is quite moist and either before or after the growing season. In tropical areas photography that follows the harvesting of such rank growing crops as sugar cane may be most timely.

Topographic indicators

The relevance of topographic considerations to flooding is so obvious that at first one may wonder why it merits mention here. But even if large-scale topographic maps were available for all regions, which is far from the actual case, the use of airphotos would still be justified. Micro-relief, (changes in elevation of less than the contour interval) is one of the most important of the topographic considerations, because it is a definitive indicator of certain erosional and depositional conditions and soil types. In some areas mounded soils which have a relief measured only in decimeters are found adjacent to, but not on, flood plains of small streams. The boundary of these soil types, so conspicuous on photos, accurately defines the extent of all but the most infrequent floods. No topographic map is made which does not lose some detail of relief between the contour lines that is relevant to flood susceptibility determination. When the scale of the photography is too small and/or the relief is too subtle for this relief perception, it may be accurately inferred from study of soil drainage patterns, photo tone changes and vegetation characteristics. Such detail is significant where soil drainage measures are to be carried out or where a river develops a flood plain on particularly flat terrain such as a coastal plain. On a somewhat larger scale, complex slopes along stream channels testify to local but intense scour and deposition.

Although all physiographic indicators except bedrock structure and compsotion may be derived from a topographic map, many of the geomorphic indicators, even larger ones, are lost between the contours. Study of all pertinent flood indicators can never be done from a topographic map, whereas the airphoto comes close to being the ideal base. The largest scale photography possible facilitates study of micro-relief and when available, coverage avoiding the growing season should be used.

Pedologic indicators

The indicators in this class have a high degree of dependence upon the indicators already discussed because the influence of climate, topography, and parent material upon soil formation is so great. As a result it becomes more difficult to discuss indicators as isolated entities. Indeed they are not! Like other clues to flood characteristics, they are closely interrelated. Especially when considered in conjunction with geomorphic indicators they can be very definitive.

The fine grained organic rich sediments characteristic of oxbow lakes, filled channels and backswamp areas, testify to quiet water deposition. Long inundation periods can be expected here. Scour marks too may exhibit a veneer of sediment with this texture, since they also are topographic depressions in which a small volume of water will be ponded. However, the foundation conditions underlying these features which exhibit rather similar surface textures, are almost certain to be significantly different. Urban development and levee construction are both critically dependent upon subsurface conditions which may be inferred from airphotos as engineers have been doing, preparatory to intensive investigations, for about 20 years.

In arid areas, the white distinguishing badge of alkali on airphotos helps define subtle depressions and the movement of groundwater.

Soil permeability and drainage possibilities are closely related. It may be entirely feasible to lower the water table on a sandy flood plain but impractical or at least less successful in many clay soils. These soils can be distinguished on photography even of forested areas in undeveloped regions.

Erosion in the usual sense of the word is absent from flood plains. The low gradients of most flood plains and the changes wrought upon them by flooding prevent development of anything but scour marks from water leaving, or returning to, the channel. It is important on photos to distinguish between scour marks caused by flood water returning over a terrace edge and normal terrace face erosion.

The type, distribution and freshness of flood sediment is one of the best indicators of flood susceptibility. Sequential photography may reveal marked differences in the appearance, of areas subject to deposition which reflects timing of the photography relative to flooding. A deposit of fresh sand only a centimeter thick will appear just as white on post-flood photography as do thick sand drifts. Care must be taken not to over-estimate sediment damage because of the conspicuous appearance of fresh sediment. Photography which does not coincide with an immediate post-flood period is more reliable in this respect than that which does coincide. Distinction is more easily made between major and minor sand accumulations on the basis of tonal differences and other modifications when at least one growing season has elapsed between the time of deposition and photography.

Socio-Economic indicators

If the pedologic indicators exhibited a degree of dependence upon other indicators, the socio-economic do even more so. In this class are presented man's adaptations to and his conflicts with the flood-plain environment. The background of other observations which we have built up allows very accurate and meaningful interpretation of these indicators in terms of flood characteristics. Generations of flood-plain residents have in some measure succeeded in synthesizing the information we have been discussing, albeit most of this has been done by rural residents. When they have struggled with the flood plain instead of adapting to it, their reasons can often be determined by airphoto interpretation.

Burton has dealt at length with the adaptations of farmers to flood plains, including the paradox involving flood hazard awareness and non-adaption. A knowledge of local agriculture and economic conditions is certainly essential to get the most from socio-economic indicators in rural areas. Indeed for this work an airphoto interpreter must have an insight into the sociological conditions in the area. The farmer's decision-making process is influenced to a large extent by his motivation, which cannot be seen and not always inferred from airphotos. In fact we cannot always infer that he is motivated to maximize his monetary income as witnessed by the submarginal farmers in every country in the world, some of whom consciously forego financially advantageous urban employment alternatives. Nonetheless, a high proportion of the (flood-plain) environment factor-land use relations that were studied can readily be examined on air photographs, and their significance weighed in the light of other indicators. As Burton noted, the land use intensity-flood frequency relationship is rather weak, but in his study he explained the exceptions encountered, as for example, the lack of non-flood-plain land to farm intensively, may force a farmer to crop even highly flood susceptible areas. One need not interview a farmer to ascertain such limitations to his land, a photograph will do as well. There is therefore, little danger of interpreting intensive use as indicative of a low frequency of flooding, especially in the light of other airphoto evidence to the contrary. On many flood plains there is a clear decrease in land use intensity with increasing flood frequency despite the exception just noted. Flood alleviation measures taken by local residents are accurate indicators of a high frequency of flooding, though these activities must be considered in the light of local economic and other conditions. Stream channel straightening, ditching and building of artificial levees by farmers indicate the location and extent of flood problems.

Land use boundaries on some flood plains coincide closely with lines separating areas of rather marked differences in flood hazard as determined from other evidence, thereby indicating a keen flood hazard awareness on the part of the farmer. This awareness of flood hazard by farmers is particularly evident in the case of farm house location and slightly less so for other buildings, though exceptions occur. In urban areas, the type, location and condition of buildings may or may not have a close relationship to flood frequency. Rundown dwellings are often noted on very susceptible areas, but extreme exceptions occur in the case of some recent housing developments where expensive homes are located on "choice" streamside lots. In the latter situation it may be necessary to examine photos predating the development to determine flood susceptibility. In some situations the flood hazard is then so obvious as to suggest that ignorance of the hazard which can honestly be attributed to the purchasers, cannot be attributed to the developer. It must be admitted in defence of some developers however, that what is glaringly evident on photographs may be relatively inconspicuous on the ground.

Intensely increased runoff and sediment damage can be anticipated from areas subject to injurious logging practices or land development. New housing developments in rolling countryside contribute vast amounts of sediment during the construction stage and greatly increased runoff thereafter, as many a suburban dweller has learned to his sorrow. Study of socio-economic indicators is perhaps best facilitated by examination of photos spanning as long a time period as possible.

Summary

In the foregoing analysis I have endeavoured to show, among other things, the importance of certain specific flood susceptibility indicators, and indicator classes, but did not attempt to place priorities on them. This is not as easy as one would no doubt tend to imagine, because priorities tend to differ considerably with respect to desired objectives. If for instance one is concerned with a macro view, then one would probably be inclined in the initial stages of the inquiry to focus primarily on the meteorologic and physiographic indicators. On the other hand, if one's purpose is to examine in detail a relatively small area, then one, while not ignoring the previously named indicator classes, would be prone to place the greatest emphasis on the topographic and socio-economic indicators. However, this priority rating does not pretend to have universal applicability especially when it is recalled that flood susceptibility indicators have varying significance and import in various cultural, climatic and geographic regions of the world. For this reason it must be emphasized that meaningful analysis and interpretation must be based on the most appropriate combination of indicators that are dictated by the problem.

In sum, this paper has attempted to illustrate various ways in which airphoto analysis and interpretation can be profitably applied to flood-plain studies and by implication to watershed studies. I have shown at some length that airphoto interpretation is all-embracing in the sense that in its presentation of a comprehensive view of say a flood plain, it must perforce draw heavily on factors which fall within the purview of most disciplines in the natural and social sciences. One of the implications of this fact is that adequate studies of flood plains and watersheds are interdisciplinary activities, and airphoto analysis provides an integrative rôle based on a fairly comprehensive view of the region as a whole.

REMARKS TO THE PANEL ON FLOOD HAZARD REDUCTION

MEETING OF FLOOD EXPERTS

DISASTER ASSISTANCE PROJECT

NATO COMMITTEE ON THE CHALLENGES OF MODERN SOCIETY

Venice, 20th October, 1970

Dr. Lawrence C.N. Burgess, Canada

I should like to preface my first remarks with the observation that they were written with the thought in mind that they would provide a framework or context into which I might fit the body of my remarks. Fortunately or unfortunately they appear to provide another sort of background to this meeting, than that so well presented by the representatives from our host country and Germany this morning. I say fortunately, because there may be some merit in my approach as a generalist, but perhaps unfortunately because I did not, and do not intend to be so presumptuous as to consider that I would set the stage for our meeting, at this afternoon's panel discussion.

Having said that, I should like to continue with a rhetorical question: "What is a flood expert?"

Presumably he is one very knowledgeable about the flood phenomenon and hopefully therefore knowledgeable about ways to reduce flood hazards. The flood phenomenon must at least embrace meteorology, especially precipitation, geology, especially erosion and sedimentation, hydrology, especially runoff and probability, geography, especially attitudes and land use, economics, especially damage appraisal, and public health, especially disaster assistance. Are any of us then experts? Collectively perhaps we are, singly, I can only speak for myself in the negative.

However, I do wish to bring to this panel such limited expertise as I have, and which I believe may be of unusually broad applicability.

The aforementioned aspects of the flood phenomen which encompass such a variety of disciplines, not only range more widely than the experience or competence of most of us, but are otherwise difficult to draw together in a meaningful consideration of, or attack on, the flood problem. A surprisingly effective integration of these considerations is found in the appearance, characteristics and uses of the flood plain surface and its relation to the watershed upland. This integrated consideration of the flood problem and measures to alleviate it, can be accomplished rapidly, economically and accurately, through interpretation of available non-flood aerial photographs. Flood photography, that is photographs of rivers during flood stage, is much more commonly associated with flood problems, and while valuable for specific purposes, is much more limited in applicability. I should mention here the ready availability of non-flood aerial photographs in all NATO countries which eliminates acquisition costs.

What then are the measures that can be implemented to alleviate flood hazards?

Measures to reduce flood hazard risks to human life and property, I believe fall into four main types or classes, namely:

(1) Evacuation.

(2) Emergency Protection (sand bagging, pumping, etc.).

(3) Prevention (dams, levees, drainage ways, etc.).

(4) Adaptation (rational land use, flood plain zoning, flood proofing, insurance, etc.).

It may be useful to make a comparison of some characteristics of the types of flood hazard reduction measures, in order to place them in proper prospective within the context or framework of national socio-economic activity and at the same time rate their suitability for the application of airphoto interpretation techniques (see Table 1 attached).

Given the degrees of development which many floodplains exhibit, and human nature being what it is, Table 1 makes it clear that no one type of measure is ideal for all situations. Low-cost, easily implemented emergency measures entail great risk and only reduce damage, while contributing little to long-term hazard reduction, economic growth, or institutional development. On the other hand, low risk measures that can contribute to, and be integrated with the economy and the institutional framework, are difficult to implement and perhaps very costly.

It is not my purpose here to discuss at further length the pros and cons of these different flood hazard reduction measures, which might reflect my preference for the non-structural, planning approach, but rather to focus on the possible application of airphoto interpretation to each of the four types of flood hazard reduction measures.

It is obvious that the time appropriate for initiation, and available for implementation, is different for each type of hazard reduction measure. As a generalization, it seems true that the earlier the measures are taken, the more satisfactorily they serve, at least in terms of lessening risks. The reasons for this are, I believe, twofold. The earlier implemented measures can, if necessary, be followed by later measures. Secondly, the early measures generally follow from rational premeditated decisions (though they may reflect emotional post-flood reaction), while measures taken later may be little more than hasty response to an emergency situation that need never have been.

It is equally obvious that there is little time available for airphoto interpretation to aid in planning Evacuation Measures. Let me only make two points in this regard. First, the identification of the type of flood hazard to which an area on the floodplain is subject, or conversely, the aerial distribution on the flood plain of certain of the flood hazards, may be determined from non-flood photographs as outlined in my paper in the conference background material which you already have. (Airphoto Interpretation as an Aid in Flood Susceptibility Determination.) The flood hazards most pertinent to emergency evacuation are water velocity and depth. Secondly, aerial photography of previous floods, preferably vertical photographs, is useful in providing information on the aerial distribution of floodwaters for a given stage, and especially in relation to transportation routes. All in all, airphoto interpretation is of limited applicability in planning emergency measures, unless done well beforehand and of practically none in an ad hoc or last minute evacuation crisis situation. I have some flood and non-flood pictures from a report with me that could serve as a basis for discussion with anyone interested in assessing their value to evacuation operations.

In regard to Emergency Protection, the same conditions apply. Flood photography of previous events has merit in depicting the distribution of floodwaters at specific stages, but the photography should be utilized in emergency protection planning, well ahead of time. More useful, I should think would be the non-flood photography, which with considerable accuracy allows delineation of those areas subject to each of the pertinent flood hazards of frequency, velocity, erosion, sedimentation, debris, depth, inundation period and areal extent. From the many clues which the flood plain offers, each hazard may be evaluated and appropriate measures planned. I should note here that indications of these hazards are Meteorologic, Physiographic, Geologic, Pedalogic, Biologic and Socio-Economic or Cultural.

While this is a slightly different and hopefully improved typology from that presented in my 1967 paper, to which I have already referred, it still relies on three basic premises. These are:

(1) any aerial photography of a flood plain is a post-flood photograph, since it is only a short time geologically, and probably only a short time in human terms since the last flood;

(2) individually and cumulatively, floods leave their "finger prints" on the flood plain; and

(3) plants, animals and man have adapted to the flood history of every stream.

These adaptions, along with the "finger prints" and meteorologic, physiographic and geologic considerations can be interpreted to yield valuable flood-plain information.

As to Preventive Measures, the third type, these are primarily engineering operations such as construction of dams and dikes and at least in North America, civil engineers have been using airphoto interpretation for such work for some 25 years.

Adaptive measures of flood damage mitigation necessitate a reliable appraisal of the nature and magnitude of the flood hazards. These have never been provided in standard flood information reports, as I note in the paper which you have. However, I believe that those "extremists", if I may use the term, who would abandon all flood plains to the river, and those who would dam, dike, and when necessary evacuate, and thereby facilitate uncontrolled development of all flood plains could compromise. An optimum trade-off between no development with little risk and uncontrolled development with acceptable risk could be attained if the complete message that the flood plain tells, were read through photo interpretation, and taken under considered advisement.

In closing, I would like to hear you with a truism. The person who can extract the most information about flooding from a photograph is the person who has the most familiarity with flood problems and the local area. However, he is the one least likely to utilize them because of the mistaken belief that he can learn nothing from them. This is in no way meant as an admonishment, but it is too often the case that those who could benefit most are those least likely to benefit at all.

Again I might mention the photographs which I have which I would be pleased to discuss with anyone so interested. I have tried not to lecture to you and hope I have fulfilled my task of stimulating discussion.

TABLE 1

CHARACTERISTICS OF FLOOD HAZARD REDUCTION MEASURES

Flood Hazard Reduction Measures	CHARACTERISTICS						
	Degree of Risk	Short Range Cost	Long Range Cost	Ease of Implementation	Constraints on Future Action	Relevance to Socio-Economic Planning	Applicability of Airphoto Interpretation
Evacuation	High	Low-Moderate	Moderate	High	Low	Low	Low
Emergency Protection	High	Moderate	Moderate	High	Low	Low	Low
Prevention	Low-Moderate	High	Moderate-High	Moderate	High	Moderate	Moderate
Adaptation	Low	Low-High	Low-Moderate	Low	Low-	High	High

A STATEMENT OF POLICY

Flood Plain and Conservation Lands

The following is a summary of the policy of the Metropolitan Toronto and Region Conservation Authority as adopted 2nd September, 1959, and contained in full detail in the Plan for Flood Control and Water Conservation.

There are three basic approaches to flood control and water conservation:

(a) construction of flood control and water conservation dams and reservoirs;

(b) construction of channel improvements and diversions;

(c) control of the use of lands in flood areas.

The rapid growth of the Metropolitan Toronto region has resulted in the encroachment of urban development on flood vulnerable lands. The cost of occupancy of flood plain lands in terms of flood damages and loss of life was demonstrated by flood Hazel, October 1954, to be too high to justify the use of flood plains for most purposes. However, the location of roadways, railways, bridges, sewers and other public utilities on flood plain lands is in many cases justifiable and unavoidable. The use of flood plain exclusively for low risk, safely designed and protected public structures, or for farming and public parks does not create serious flood damage problems.

The construction of protective works to permit development of flood plain lands is neither economically possible nor desirable.

> "It is the flood control policy of Metropolitan Toronto and Region Conservation Authority to pursue a comprehensive programme of flood control measures consisting of a combination of (1) the construction of protective multi-purpose dams and reservoirs and protective channel improvements; and (2) the acquisition of flood plain land at equitable prices wherever feasible, and the zoning and regulation of flood plain lands where acquisition is not feasible or desirable. Further, it is the policy of the Authority to pursue a comprehensive programme of ancillary conservation measures and a programme of development of recreation and park lands in such a way as to maximize and perpetuate the benefits bestowed by nature."

Flood Line Maps

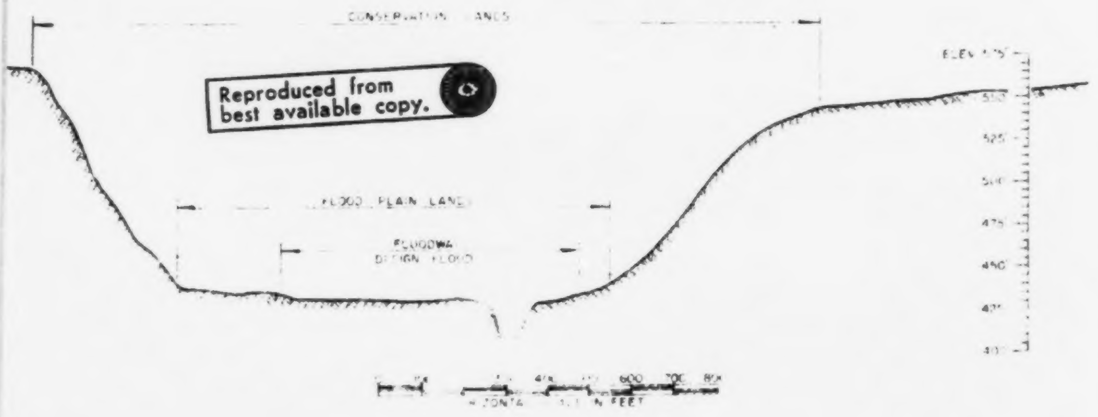
The Ontario Department of Commerce and Development established high water marks following the flood of 15th October, 1954 on all of the major rivers under the jurisdiction of the Authority. The Department purchased flood line maps from the Photographic Survey Corporation in 1954, of the Humber River. The Metropolitan Toronto and Region Conservation Authority has extended the map coverage to include all of the river basins within the region under the jurisdiction of the Authority.

In addition, the Authority has engaged consulting hydraulic engineers to determine the magnitude of floods of the intensity of Hurricane Hazel as centred over the Humber watershed. The flood lines of these greater floods are also indicated on the flood line maps and are designated the stages for the design flood. The flood line maps are at a scale of 200 feet to the inch with a 5 foot contour interval, 2½ foot interpolation. The actual high water marks of Hurricane Hazel, as established by the Ontario Department of Commerce and Development following Hurricane Hazel, are indicated on the plans. In addition, the high water marks for the design floods are indicated. The plans include not only the flood plain but in addition, cover the entire valley system together with adjacent table lands.

The following is the policy of the Authority for the distribution of these maps:

Private individuals	$25.00 per sheet
1 complete set to be provided to every municipality within the region at no cost. Additional prints for municipalities.	$ 5.00 per print

Reproduced from best available copy.



TYPICAL CROSS SECTION OF RIVER VALLEY

The flood line maps must be ordered through the Authority. The maps form the basis for the flood plain and conservation land studies undertaken by the Authority.

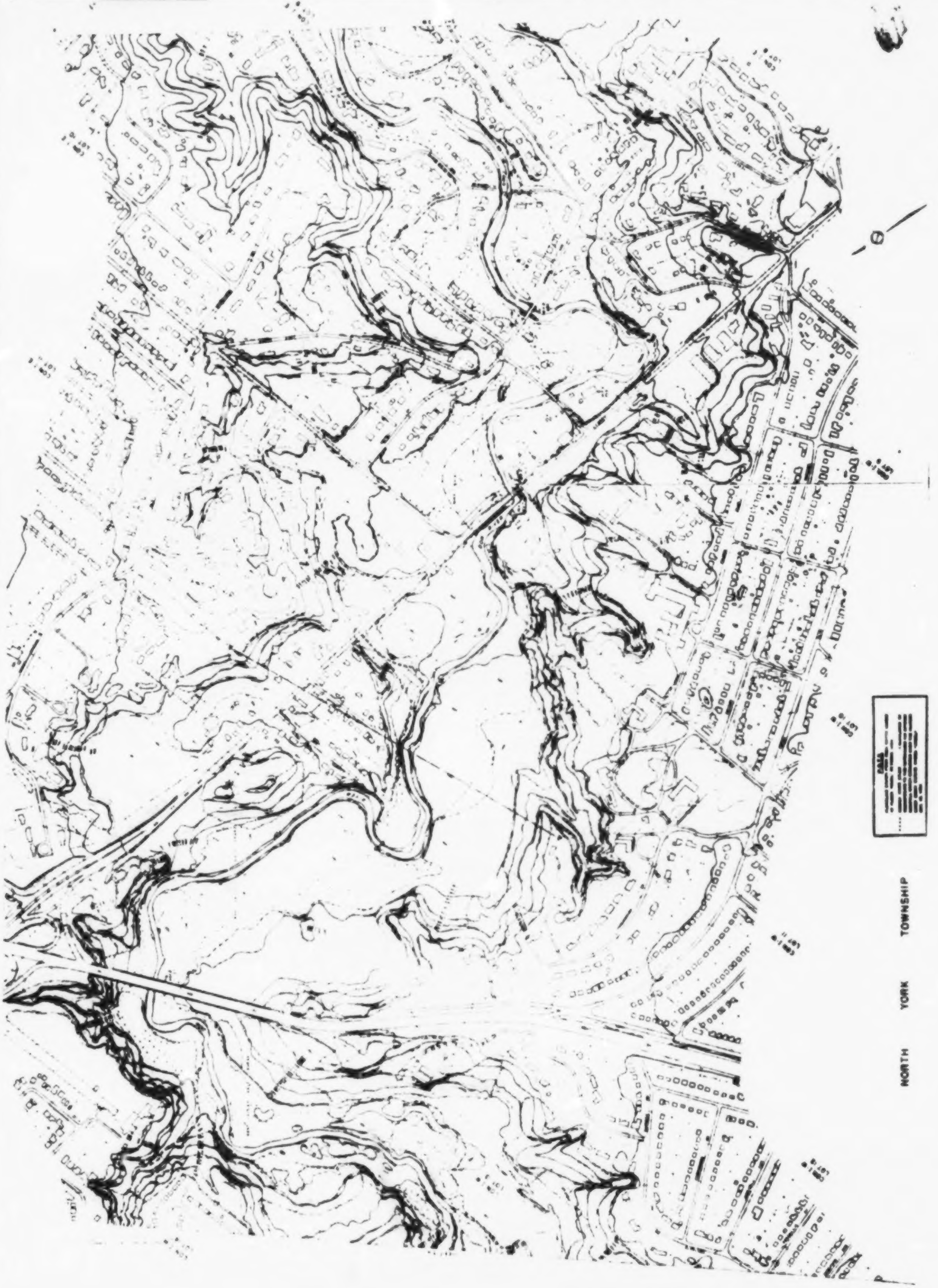
Zoning and Regulations

Wise flood plain management involves the best use of the lands and resources as an integral part of the development of the region. Multi-purpose dams and reservoirs, other flood protective measures and regulated use of areas marginal to the streams and reservoirs must all be considered. The adjustment and control of land use to provide for the needs of the river valleys to carry flood waters are important parts of the flood control and water conservation policy of the Metropolitan Toronto and Region Conservation Authority. The power to regulate the use of flood plain lands is given to municipalities under Section 30 of the Planning Act.

> Section 30(a). For prohibiting the erection of a building or structure for residential or commercial purposes on land which is subject to flooding or on land where, by reason of its rocky, low lying, marshy or unstable character, the cost of construction of said waterworks, sewerage or drainage facilities is prohibitive.

The Conservation Authority is requesting all municipalities within the region under the jurisdiction of the Authority to pass by-laws designating floodways, i.e. all lands subject to flooding by the design flood "a flood equal to the intensity of Hurricane Hazel centred over the Humber watershed". The flood line maps provided by the Authority will form the basis for the designation of the floodways. The co-operation of the municipalities is required for the Authority to be able to achieve its flood control and water conservation objectives.

The main valley systems throughout Metropolitan Toronto and in some instances extending into adjacent municipalities have land use restrictions placed on them, either by the use of official plans or restricted area by-laws (zoning by-law). There is a multiplicity of definitions covering these land use zones. They include greenbelt, open spaces with a variety of definitions such as public open space, private open space and semi-public open space. In other instances, they have been termed conservation lands. The permitted uses within these zones vary from municipality to municipality. The policies of the various municipalities for the amendment of the greenbelt and open space boundaries also vary considerably. Some municipalities are permitting encroachments on valley slopes, both by buildings and by lots. In many instances, steep valley slopes are used as coverage for apartment developments. The effects of these encroachments on valley slopes is well illustrated throughout the


NORTH YORK TOWNSHIP

Metropolitan region. Many developers constantly dump fill over these slopes and leave them in a condition that destroys the natural vegetation and the natural amenities of the valleys. Other municipalities are refusing to permit development of valley slopes and all efforts are taken to prevent encroachment.

The Metropolitan Toronto and Region Conservation Authority is of the opinion that the following designations should be applied to the main river valleys under the jurisdiction of the Authority.

(1) Floodways - Those lands subject to flooding by design flood.

(2) Public Open Space - Those lands contained within the main valley systems from crest of slope to crest of slope that are scheduled for acquisition by the Authority as flood plain and conservation lands or by the municipality.

(3) Greenbelt or Private Open Space - Those lands contained within the main valleys under the jurisdiction of the Authority from crest of slope to crest of slope, but not presently scheduled for acquisition by the Authority or the municipalities.

The floodway designation will be included within the greenbelt designation in order to have absolute control over land use in the floodways.

A sample by-law which designates floodways in the Township of Etobicoke is appended to this report for reference.

Acquisition of Flood Plain and Conservation Lands

The policy of the Metropolitan Toronto and Region Conservation Authority is to acquire the flood plain and conservation lands in the downstream sections of the main valley systems under the jurisdiction of the Authority. The Authority is of the opinion that for adequate control of these lands for flood control and conservation purposes, it is essential that they be owned by a public agency such as the Authority. The ownership of these lands therefore ensures their proper use in order that the objectives of the Authority can be achieved. The flood plain and conservation lands in public ownership can be used for other than flood control and conservation purposes for they provide an opportunity for the provision of public open spaces and recreation facilities that are an essential feature of every urban development. The Authority has acquired major acreages of flood plain and conservation lands in the main valleys within Metropolitan Toronto and proposes the extension of this plan to cover the lower reaches of all the major watercourses under the jurisdiction of the Authority. These lands have been acquired under what are known as Water Control Schemes. The schemes set forth the lands to be acquired, the estimated cost of the acquisition, the purpose for which the lands were to be used, and the scheduling of acquisition.

The majority of water control schemes adopted to date have been in the Municipality of Metropolitan Toronto, and this municipality has been designated as the benefitting municipality and required to pay 50% of the cost of the acquisition of flood plain lands. The Province of Ontario contributes the remaining 50% of the cost. Under the provisions of the agreement entered into on 14th June, 1961 between the Authority and the Province of Ontario, the Authority will acquire an additional 7,600 acres of flood plain land over the next ten years. The cost of this land will be shared equally between the Authority and the Province.

In addition to the acquisition of flood plain and conservation lands, the Authority is responsible for the undertaking of conservation measures required for the control of stream bank erosion and for the development of the watercourses for flood control purposes. Some water control schemes include these works as part of the scheme, whereas others are undertaken as additional schemes after the lands have been acquired and development for recreation purposes has been completed.

In many instances, municipally owned lands are included in water control schemes. The policy of the Authority and the Province of Ontario is that where municipally owned lands are within a scheme they must be transferred to the Authority for a nominal sum. The Province of Ontario will not pay grants for municipally owned lands included in water control schemes. Most of the municipalities within Metropolitan Toronto and in several instances outside Metro have co-operated with the Authority in the transfer of these lands to the Authority. The Authority assumes all survey and legal costs involved in the transfer of municipally owned lands.

Recreation and Ancillary Conservation Measures

The acquisition of flood plain and conservation lands is of tremendous value for the elimination of the risk of future heavy flood damage, the probability of heavy loss of life and, in addition, provides ancillary benefits from the standpoint of recreation and conservation. The Authority proposes to utilize the acquired flood plain lands to the fullest possible extent for recreation purposes, maintaining a balance between forest tracts and recreation park lands. The flood plain lands lying within the limits of Metropolitan Toronto are leased to the Municipality of Metropolitan Toronto for development, maintenance and administration by the Metropolitan Parks Department. The Authority maintains ownership of the lands and must approve all plans of development to ensure that the efficiency of the valleys to function as a floodway is not jeopardized. Picnic facilities, play areas, nature study and wildlife areas will be included in the development of flood plain lands. The Authority proposes to reforest areas of flood plain and conservation lands where required.

The full cost of the development of flood plain and conservation lands for parks and recreation purposes is borne by the municipality (Metropolitan Toronto, when located within Metro) in which these lands are situated. The Authority does not have funds for the development, maintenance and operation of these lands.

Maintenance of Watercourses

The Metropolitan Toronto and Region Conservation Authority does not have direct control over all of the drainage courses in the region under the jurisdiction of the Authority. Control of these watercourses is accomplished by the Authority through the acquisition of the adjacent lands. A large portion of the watercourses throughout the region are in private ownership and the Authority does not have any jurisdiction over these watercourses. The Authority does not have power nor does it have funds to undertake channel improvement and erosion control measures on valley properties that are owned privately or by municipalities. However, the maintenance of watercourses is an important flood control measure within the Metropolitan region. The Municipality of Metropolitan Toronto has assumed some responsibility for the maintenance of the major river valleys within Metro and this is set forth in the minutes of the Metropolitan Council adopted on 7th February, 1961 and included as Appendix D.

The Authority does have jurisdiction, however, over the filling of flood plain lands and river beds. The Authority has enacted regulations under Section 20(1)(d) of The Conservation Authorities Act. These regulations and the procedure for the administration of the regulations are set forth as Appendix C to this report.

APPENDICES

APPENDIX A

The following excepts from the Conservation Authorities Act, R.S.O. 1960, Chapter 62, are the basic statutes that govern the work of the Authority.

Sec. 15 - The objects of an authority are to undertake and effect such scheme or schemes in respect of of the watershed or part thereof for which it is established as the authority determines; R.S.O. 1950, c.62, s.13.

Sec. 1 - "Scheme" means a scheme undertaken by an authority for the purposes of conservation, restoration and development of natural resources, other than gas, oil, coal and minerals, and the control of water in order to prevent floods and pollution, or for any such purposes; R.S.O. 1960, c.252.

Sec. 17 - For the purposes of carrying out a scheme, an authority has power,

(h) to use lands that are owned or controlled by the authority for such purposes, not inconsistent with its objects, as it deems proper;

(i) to acquire lands, with the approval of the Minister, and to use lands acquired in connection with a scheme, for park or other recreational purposes, and to erect or permit to be erected, buildings, booths and facilities for such purposes and to make charges for admission thereto and the use thereof.

APPENDIX B

TOWNSHIP OF ETOBICOKE

BY-LAW # 11,757

A BY-LAW TO PROHIBIT THE ERECTION OF BUILDINGS AND STRUCTURES FOR RESIDENTIAL OR COMMERCIAL PURPOSES IN PART OF THE TOWNSHIP OF ETOBICOKE

WHEREAS aerial photographs have been taken showing the high water line reached by the waters of the Humber River and its branches in October 1954, and from which photographs contour maps have been compiled showing such line as a dotted line thereon, copies of which maps are attached to and form part of this by-law;

AND WHEREAS such high water line varies considerably in its location and it is deemed desirable to more accurately define the line of reference to contour lines for the purposes of this by-law;

AND WHEREAS it is deemed expedient to prohibit the erection of buildings and structures for residential or commercial purposes in that part of the Township of Etobicoke lying within the bed of the Humber River and its branches, and lying between the red lines marked on the said maps and the normal bed of the Humber River and its branches, by reason of the fact that such land is subject to flooding. NOW, THEREFORE, THE MUNICIPAL COUNCIL OF THE CORPORATION OF THE TOWNSHIP OF ETOBICOKE ENACTS as follows:

1. No person shall erect any building or structure for residential or commercial purposes in that part of the Township of Etobicoke lying in the bed of the Humber River and any of its branches, and between the red lines as designated on the maps attached hereto, and the normal bed of the Humber River and its branches, provided, however, that this by-law shall not operate to prohibit the erection of buildings and structures designated to be used in connection with the use of the said lands for parks or recreational purposes.

2. This By-Law shall not apply to any building or structure which, on the day of passing of the By-Law, is erected on the said lands, nor shall the By-law apply to any building or structure the plans for which have, prior to the day of the passing of the by-law, been approved by the Building Commissioner so long as the building or structure, when erected, is used for the purpose for which it was erected.

3. Any person convicted of a breach of any of the provisions of this By-law shall forfeit and pay, in the discretion of the Convicting Magistrate, a penalty not exceeding the sum of Three Hundred Dollars ($300.00) exclusive of costs, for each offence, and every such penalty shall be recoverable under The Summary Conviction Act.

4. The provisions of Clause 3 shall be in addition to any other remedy which the Corporation of the Township of Etobicoke or a ratepayer thereof may have to restrain by action a contravention of this By-law.

5. Subject to the approval of The Ontario Municipal Board, this By-law shall come into force and take effect upon the date hereof.

READ a first, second and third time and passed in Council this 5th day of November, A.D. 1956.

W.B. LEWIS
Reeve

S.W. ECKERSLEY
Clerk

APPENDIX C

THE METROPOLITAN TORONTO AND REGION CONSERVATION AUTHORITY THE CONSERVATION AUTHORITIES ACT

O. Reg. 91/60
Metropolitan Toronto and Region
Dumping Fill
Made - 2nd March, 1960
Approved - 25th March, 1960
Filed - 11th April, 1960

REGULATIONS MADE BY THE METROPOLITAN TORONTO AND REGION CONSERVATION AUTHORITY UNDER THE CONSERVATION AUTHORITIES ACT

1. In these regulations,

(a) "Authority" means The Metropolitan Toronto and Region Conservation Authority.

(b) "fill" means fill of any kind.

2. Subject to regulation 3, no person shall place or dump fill or permit fill to be placed or dumped in any area below the high water mark of any river, creek or stream in the area under the jurisdiction of the Authority.

3. Subject to The Ontario Water Resources Commission Act, 1957, or to any other private interest, the Authority may permit in writing the placing or dumping of fill in an area below the high water mark, if, in the opinion of the Authority, the placing or dumping does not interfere with the ability of the river, creek or stream to safely carry the maximum flood flows and will not result in pollution of the river, creek or stream.

4. No dumping or placing of fill below the high water mark of the river, creek or stream shall be commenced until the registered owner of the property has obtained the permission required by regulation 3.

5. Applications for permission to place or dump fill shall be filed with the Authority and shall include:

(a) two copies of a plan of the property on which the fill is to be placed, showing the proposed location of the filling, the depth to which it is proposed to fill and the proposed final grade of the land when filling is completed;

(b) a complete description of the type of fill proposed to be placed or dumped;

(c) a statement of the dates between which the placing or dumping will be carried out; and

(d) a statement of the proposed use of the land following completion of placing or dumping.

6. The Authority may, at any time, withdraw permission to place or dump fill if, in the opinion of the Authority, the representations contained in the application for permission to place or dump the fill are not carried out.

ADMINISTRATION

The Administration of the Regulations is set forth in Executive Res. No. 163 Executive Meeting No. 13, 10th August, 1960, as follows:

That the report of the Regulations Sub-Committee be received and that the recommendations contained therein as amended and set forth herein be adopted:

1. The Director of Operations is hereby appointed as the officer to enforce the regulations of the Authority regarding the dumping of fill.

2. The duties of the Officer shall be:

(a) to enforce the Regulations;

(b) to investigate complaints and to make observations on the filling of flood plain lands and take the necessary and proper action to abate nuisances therefrom;

(c) to issue permits and notices under these regulations and to keep records of applications, plans, specifications, permits, violations, complaints and other matters on file for Authority purposes only;

(d) to examine the plans and specifications for all areas where it is proposed to fill flood lands which meet the requirements of these regulations;

(e) to inspect areas where permits have been issued for the dumping of fill on flood plain lands;

(f) to enlist the co-operation of civic, technical and contractor groups in respect to the control of dumping of fill on flood plain lands.

APPENDIX D

MAINTENANCE OF WATERCOURSES

The Works Committee recommends the adoption of the appended report (6th December, 1960) received from the Commissioner of Works, viz:

"Within the Metropolitan boundaries there are approximately 200 miles of river and stream channels; some large, such as the Humber and Don Rivers, and others small, similar to the Black and Wilket Creeks. These channels all serve as outlets for precipitation which falls on the Metropolitan Area in the form of rain and snow, and should be regarded as a major municipal facility in much the same manner as the sanitary sewer system.

"In order to promote their maximum usefulness, these watercourses should be maintained free of obstruction. As a result of inadequate care, unsatisfactory conditions can arise, such as:

(a) Debris strewn along the river and, in many instances, log jams causing flooding to varying degrees.

(b) Ice jams, which could cause serious flooding.

(c) Eroded earth material, subsequently deposited in the ponding areas behind dams, destroying the effectiveness of the purpose for which the dam was constructed.

(d) Unsightly appearance of the river channels, caused by logs, branches, oil cans, and other items of junk too numerous to mention.

(e) Unnecessary silting, such as in the lower Don, which tends to accumulate in the Toronto Bay, requiring annual and expensive dredging.

"By the institution of a modest annual cleaning programme along the channels of all the rivers and the shores adjacent thereto, the following benefits would accrue:

(1) Reduction in local flooding conditions.

(2) Reduction in silting in the bay.

(3) A tidy appearance of the river channels, particularly adjacent to Conservation Authority and Metropolitan Parks areas.

(4) Elimination of unsightly and unhealthy pollution pockets, which build up with the accumulation of twigs, logs and oil drums.

"At many locations the Conservation Authority has completed flood control schemes, the maintenance of which is not normally financed by the Authority, but is left to the benefitting municipality.

"Much of the shoreline of the water channels is owned privately, while extensive land adjacent to the waters is owned by the Metropolitan Parks Department and the Metropolitan Conservation Authority. The Metropolitan Works Department also controls certain lands along the shoreline of these streams.

"Having regard for the foregoing, it is recommended for the consideration of your Committee:

(1) that the Metropolitan Parks Department keep clear river channels and the shoreline for a distance of 20 feet from the river in location where it owns the abutting land - the Parks Maintenance appropriation assuming the charges for the work;

(2) that the Metropolitan Department of Works maintains the remainder of the river channels and adjacent shores for 20 feet back, to the extent possible in view of the fact that some of the land is privately owned. (This work could probably be done modestly with a crew of six men and one truck, together with the necessary equipment, on an annual basis.)
If this proposal is deemed acceptable, funds will be included in the Department of Works budget from this time forward; and

(3) that the Department of Works and/or the Metropolitan Parks Department maintain any flood control structures which have been built by the Metropolitan Toronto and Region Conservation Authority.
Funds for this will be looked upon as a Special Item each year.

"It should not be deemed that the Metropolitan Corporation is assuming direct responsibility for the rivers, because of privately-owned lands along the shorelines, but rather that the work is being carried out solely in the interest of rendering the rivers capable of carrying maximum flow, presenting the best appearance, and elimination of pollution pockets."

APPENDIX E

AGREEMENT WITH MUNICIPALITY OF METROPOLITAN TORONTO

MEMORANDUM OF AGREEMENT made this day of February, A.D. 1958

BETWEEN THE METROPOLITAN TORONTO AND REGION CONSERVATION AUTHORITY,

hereinafter called "The Authority", OF THE FIRST PART,

AND THE MUNICIPALITY OF METROPOLITAN TORONTO,

hereinafter called "Metro", OF THE SECOND PART.

WHEREAS The Authority has propounded a scheme for the acquisition of flood plain lands in the Lower Humber River;

AND WHEREAS Metro has been designated as the benefitting municipality and has approved the scheme of acquisition;

AND WHEREAS Metro is desirous of administering park and recreational facilities in the Lower Humber;

AND WHEREAS The Authority has obtained the approval in writing of the Minister of Commerce and Development of the Province of Ontario to the said scheme;

AND WHEREAS The Authority is proceeding to acquire all the land necessary to carry out the scheme.

NOW THEREFORE THIS AGREEMENT WITNESSETH that in consideration of the recitals herein and the carrying out of the various obligations contained in this agreement, the parties hereto agree as follows:

1. The Authority shall obtain and register in its own name all the lands necessary for the due carrying out of the scheme for the acquisition and development of flood plain lands in the Lower Humber.

2. The Authority will, upon the request of Metro, permit Metro to develop and maintain for park and recreational purposes such lands as it shall deem to have a park potential.

3. Metro will develop and maintain these lands for public park purposes with the necessary administration and supervisory accommodation in connection therewith and for no other purpose except with the approval in writing of The Authority.

4. The cost of development and maintenance of these lands and the maintenance of all other lands acquired by The Authority under the said scheme shall be borne by Metro and all plans for such development shall be submitted to The Authority for its approval in writing and unless and until such approval is obtained no work shall be started.

5. If fill is required by Metro for such development, then the consent to use of fill, the type of fill and the amount and method of using the fill shall be obtained from The Authority in writing.

6. No permanent buildings shall be erected on these lands by Metro without first obtaining the consent in writing of The Authority, both as to location and type of building.

7. Metro shall assume the full cost and responsibility for the maintenance of such park lands and other lands as set out in paragraph 4 above, provided, however, that if The Authority is of the opinion that Metro is not properly maintaining such lands, then The Authority may, on notice to Metro, enter upon the said lands for the purpose of maintaining them and any costs incurred by The Authority by reason of so doing shall be paid to The Authority by Metro forthwith upon the demand thereof.

8. The Authority shall retain control of all other lands acquired by it under the scheme, including all aspects of the river channels, flood control river protection, erosion control and dams and Metro shall not interfere with the carrying out of such works as are necessary for these projects.

9. Metro shall not alter the course of any river, brook, stream or watercourse without authority from The Authority.

10. Metro shall not have the right to lease or otherwise dispose of the park lands herein, but may permit concessionaires thereon with the approval of The Authority, the said approval to be given in writing.

11. Metro shall pay all taxes or other charges levied against the said park lands.

12. Metro covenants and agrees to indemnify and save harmless The Authority of and from any and all manner of claims, damages, loss, costs or charges whatsoever occasioned to or suffered by or imposed upon The Authority or its property, either directly or indirectly, in respect of any matter or thing in consequence of or in connection with or arising out of Metro's use, occupancy or development of the lands herein or out of any operation connected therewith or in respect of any accident, damage or injury to any person, animal or thing by, from or on account of the same. Metro covenants that the indemnity herein contained shall extend to all damages and claims for damages by reason of improper or faulty erection or construction of structures hereafter erected or installed on the said park lands or in connection therewith by Metro, its servants or agents and by reason of any insufficiency in such structures and whether or not samw have been approved by The Authority, its servants or agents.

13. This agreement shall remain in full force and effect until superseded by an agreement mutually acceptable to the parties hereto.

IN WITNESS WHEREOF THE parties hereto have hereunto affixed their corporate seals attested by the hands of their proper officers duly authorized in that behalf.

SIGNED, SEALED AND DELIVERED
IN THE PRESENCE OF:

THE METROPOLITAN TORONTO AND
REGION CONSERVATION AUTHORITY

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....

....

THE MUNICIPALITY OF
METROPOLITAN TORONTO

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MONO
ALBION
CHINGUACOUSY
TORONTO GORE
TORONTO
KING
VAUGHAN
METROPOLITAN TORONTO
WHITCHURCH
MARKHAM
UXBRIDGE
PICKERING
METROPOLITAN TORONTO AND REGION
CONSERVATION AUTHORITY

CONSERVATION AUTHORITIES IN SOUTHERN ONTARIO

A.S.L. Barnes

Introduction

Dr. Luna Leopold, Chief of the United States Geological Survey has described The Conservation Authorities Act "as one of the most advanced approaches to conservation anywhere", and Donald Williams, Chief of the Soil Conservation Service of the United States has said it is "an outstanding example of community action for conservation". It is unique in Canada, in North America and, until quite recently, apparently unique anywhere in the world. It has been studied by both professionals and parliamentarians from other Provinces, the United States, the United Kingdom and from countries in nearly every continent. This paper is presented in the hope that it will be of value to developing countries the world over.

Geographical Location

Ontario lies between 42° and 57° north latitude. It is the second largest province in Canada with a total area of 412,562 square miles which is about five times the size of Great Britain and Ireland. Its population is about six million people. Southern Ontario is that section of the province lying between 42° and 45° north latitude. It is almost entirely surrounded by three of the Great Lakes, namely Lakes Huron, Erie and Ontario, with the St. Lawrence and Ottawa Rivers outlining the eastern portion. Southern Ontario covers 36,500 square miles or about one-tenth of the total area, but nine-tenths of the population of the province live in this triangle. It is this populous and high industrialized section of the province which will be dealt with here.

Physiography(1)

Southern Ontario lies almost wholly south of the great Canadian Shield (precambrian rock) and the bedrock is composed of sedimentary limestones, sandstones and shales of ancient origin which have been faintly but noticeably warped. The whole area has been glaciated at least three times with the last ice sheet (Wisconsin) retreating about 10,000 years ago. The glacial drift averages 75 to 100 feet in depth and varies from zero in some areas to several hundred feet. The maximum elevation above sea level is 1,700 feet and the topography is mainly level to undulating clay and sand plains and rolling hills. Because of the low relief the heights of land between watersheds are not distinctly marked by ridges. The headwaters of many of the streams lie in swamps which are shallow depressions in the clay plain. Indeed in some cases two or more streams flowing in different directions arise in the same swamp. In some parts melt waters from the retreating glaciers have cut deeply incised valleys into the glacial drift and the present streams flow in these valleys.

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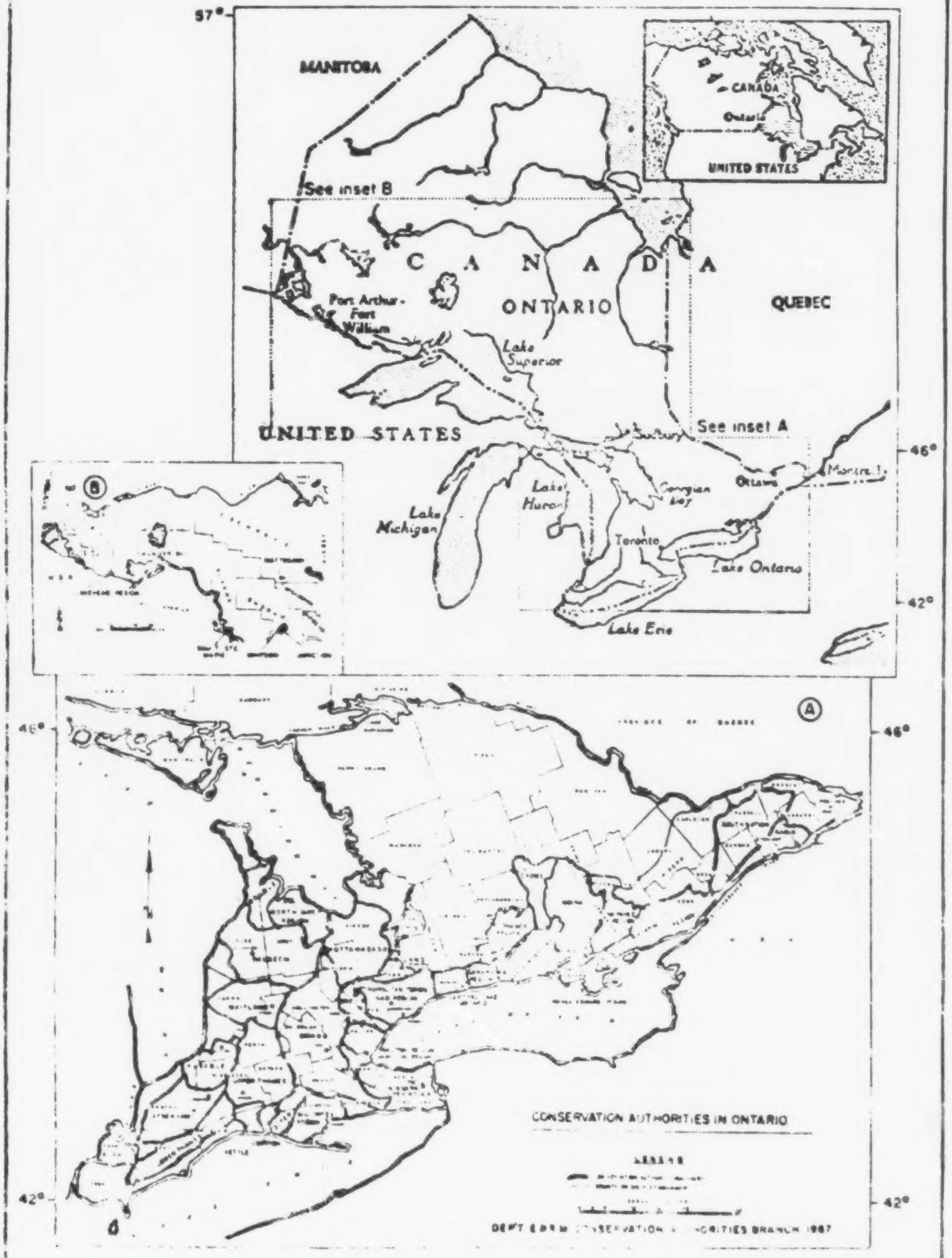
(1) Chapman, L.J. and Putnam, D.F. The Physiography of Southern Ontario. University of Toronto Press, 1966.

CONSERVATION AUTHORITIES IN ONTARIO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CONSERVATION AUTHORITIES IN ONTARIO
DEPT E P & M CONSERVATION AUTHORITIES BRANCH 1967

Prior to settlement the whole of Southern Ontario was covered by forest. This forest was predominantly a maple-beech forest on the heavier soils with extensive pine and oak forests on the lighter soils and with cedar, elm and soft maple in the swamps. Settlement began at the end of the eighteenth century and about 70 per cent of the land has been cleared for agriculture. In the last 20 years the trend in land clearing has been reversed and more than one million acres has gone out of agriculture.

The climate of Southern Ontario is a continental climate modified by proximity to the Great Lakes. Temperatures range from minus 30°F in winter to 100°F in summer, and precipitation is 30-40 inches with approximately 4-12 inches of this in the form of snow.

Prior to 1940 the possibility of a water shortage in Ontario with 17 per cent of its area covered with water and Southern Ontario almost surrounded by the Great Lakes was undreamed of. True there had been floods in the past and low stream flows in summer. Records indicate that there has been little if any change in the total amount of precipitation over the last hundred years, but there has been a marked increase in the frequency and intensity of floods and a consequent reduction in summer flow in streams. This has been aggravated by the increasing demand for water for industrial, domestic and agricultural use.

The Conservation Authorities Act(1)

Because of the concern relating to water supplies as well as other renewable natural resources The Conservation Authorities Act was passed by the Government of Ontario in 1946.

When it was passed the legislators had three premises in mind:

(1) The initiative must come from the local people.

(2) The best unit on which to co-ordinate all conservation work dealing with renewable natural resources is the watershed.*

(3) If the local people show the initiative, the Government stands ready to provide technical advice and financial assistance in the form of grants.

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(1) The Conservation Authorities Act - Revised Statutes of Ontario, 1960, Chapter 62.

* Watershed in this paper means the whole drainage area of a river basin.

Local interest may be shown first by a municipal council, a service club or any other group of conservation-minded citizens. They are then advised to call an informal meeting inviting representatives from all municipalities in the watershed and all interested citizens to attend. At this meeting a representative of the Ontario Government is present who explains how an Authority is established, what its functions are and endeavours to answer all questions.

Following this unofficial meeting if two or more municipalities (cities, towns, villages and townships) petition the Minister (Energy and Resources Management) he must call an official meeting to discuss the establishment of an Authority on the watershed or group of watersheds concerned. The Minister then sets the date, time and place of meeting and notifies all the municipalities lying wholly or partly in the watershed or watersheds.

The council of each municipality may appoint representatives to attend the meeting on a population basis, but the maximum number from any one municipality is five. A quorum for the meeting is two-thirds of the total number of representatives entitled to attend. At this meeting the whole question of establishing an Authority is exhaustively explored and methods of financing are carefully outlined. At the end of the meeting one of the municipalities which asked for the meeting usually presents a resolution requesting the establishment of an Authority. If this resolution is passed by not less than two-thirds of the representatives present it is forwarded to the Minister and the Authority is established by the Lieutenant Governor-in-Council who also designates which are the participating municipalities (including those which may have voted against the resolution) and the area over which the Authority has jurisdiction.

Conservation Authorities

Following the passing of the Order-in-Council the Minister calls the first meeting of the Authority to which each municipality appoints its representative or representatives and again the number is based on population. At this meeting the Authority elects a chairman and vice-chairman from among its own members. If an Authority receives a grant from the Government, the Government may appoint three representatives and in some cases the chairman of the Authority.

The Authority then is a body corporate and may undertake almost any project in the field of conservation of renewable natural resources. The Authority may elect or appoint an executive committee from among themselves and delegate all or any of its powers, except the power to raise money or enter into contracts, to the executive committee.

It may also appoint a number of advisory boards such as finance, water control, forestry, land use, wildlife and recreation. These boards have been proved to be most valuable not only in accelerating the work of the Authorities but also in maintaining the interest of representatives, though members of advisory boards are not necessarily municipal representatives and frequently include engineers, foresters, agrologists and biologists.

When the Authority has been established the Conservation Authorities Branch of the Ontario Department of Energy and Resources Management makes a complete conservation survey of the watershed under the Authority's jurisdiction at no cost to the Authority. This survey covers the subjects of water, land, forests, wildlife and recreation.

Subsequently a report with recommendations is prepared for the guidance of the Authority. Though the report contains numerous recommendations and may serve as a plan for the Authority to follow over a long period of years, it is the Authority itself which makes the decisions as to which projects shall be undertaken and when they will be carried out. The Conservation Authorities Branch also seconds a resource manager who is a provincial civil servant to each Authority to direct its operations under instructions from the chairman of the Authority.

The primary work of the Authorities is water control which involves the construction of dams and reservoirs to prevent floods and store water during periods of high flow in the spring and release it gradually during the summer to augment low natural flows to provide water for domestic, industrial and agricultural use as well as the dilution of sewage effluents. Where feasible the reservoirs are also used to a limited extent for recreation purposes. In addition channel improvement works are undertaken to pass flood waters safely through urban areas.

Though water is the most important of the natural resources which fall under the jurisdiction of the Conservation Authorities, the Authorities also co-ordinate the works undertaken in the other fields of resource management such as forestry, land use, wildlife and recreation. For example, some 70,000 acres of land, submarginal for agriculture, has been acquired and reforested, gully control work and the establishment of grassed waterways has been undertaken and areas, particularly wetlands, have been set aside for wildlife management. In most cases the forest and wildlife lands have been placed under agreement with the Department of Lands and Forests for management. Through the co-operation of the Department of Agriculture Authorities have encouraged farmers to reduce runoff and loss of top soil from their lands by modern methods of farming.

All Authority owned lands are used for some form of recreation - hiking, nature trails and perhaps hunting; only 3½ per cent of their lands are used for intensive or developed recreation such as picnicking, camping, boating and swimming, and about one-tenth of Authority budgets is devoted to recreational developments. However, with the increasing amount of leisure time and improved transportation facilities, the demand for recreation areas is constantly expanding. Where rivers flow through urban centres it has been the policy of many Authorities to acquire all flood plain lands along the rivers, do the necessary channel improvement work and then lease the flood plain to the municipality for a period of 99 years. The Authority retains ownership of the land and controls all building, but the municipality develops and maintains the flood plains as parkland. Under this system Metropolitan Toronto, for example, will have 7,200 acres of parklands on the flood plain lands of four major streams which flow through the city. Similar projects are being worked out in numerous urban centres throughout Southern Ontario.

Grants

In addition to making conservation surveys and providing technical assistance to Authorities, Ontario has developed a system by which an Authority can obtain very substantial grants for almost any conservation work which it wishes to undertake. These grants are not statutory grants but are policy grants and in general are 50 per cent of the cost. However, there are several exceptions under which an Authority may obtain a 75 per cent grant. Practically all administration costs including salaries and travelling expenses of members and employees, office rent and equipment, expenses connected with publicity, public relations and education are eligible for 50 per cent grants. Nearly all capital expenditures such as channel improvement work, tree planting, gully control and the development of wildlife and recreation areas are also eligible for 50 per cent grants. However, 75 per cent grants are available for preliminary engineering up to the point of calling for tenders, for the construction of small reservoirs, and for the maintenance of all water control structures. In certain cases where the Authority has prepared an overall water control plan for a whole watershed it may receive a grant from the Government of Canada under The Canada Water Conservation Assistance Act(1). Under this Act Canada will provide 37½ per cent of the cost, the Province then contributes 37½ per cent and the remaining 25 per cent is raised by the Authority by levy on its member municipalities.

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(1) Canada Water Conservation Assistance Act - Statutes of Canada, 1952-3, Chapter 21.

In fact, the Authority raises all its share of the cost of its projects by levy on its member municipalities. The amount of the levy is determined by the members of the Authority and is usually based on population, though it may be based on assessment or a combination of population and assessment. Costs of such items as administration, forestry, wildlife and recreation are spread over all member municipalities. However, costs of major water control projects are based on benefit assigned to each municipality as decided by the Authority. If a municipality is dissatisfied with its levy it may appeal to the Ontario Municipal Board.

Conclusion

The great strength of the Conservation Authorities movement lies in the local participation. Local people are closer to the problems, they raise a fair share of the funds required and take an intimate and even personal pride in the development of projects on their own watershed. At the present time there are 36 Conservation Authorities in Ontario with jurisdiction over more than 25,000 square miles. The Authorities embrace 860 representatives from 529 municipalities in Ontario. These representatives are, on the whole, dedicated to the cause of conservation; they devote a great deal of their own time to conservation work and most of them receive nothing more than a per diem allowance and mileage for meetings attended.

This is probably one of the most outstanding examples to be found anywhere of democracy working through three levels of government to achieve the wise use of the renewable natural resources in an area which is experiencing an unprecedented growth of population, urbanization and industrialization.

GUIDELINES FOR PEACETIME DISASTER COSTS ELIGIBLE FOR FINANCIAL ASSISTANCE

(Canada)

1. The purpose of this paper is to provide guidelines for officials who are responsible for determining those eligible costs which can be directly associated with a disaster/emergency and its immediate effects as a basis for cost sharing arrangements between governments.

2. The guidelines do not refer to projects designed to reduce vulnerability in the event of recurrence of a disaster or to assist the post-disaster economy of an area or community, as these, while very important, are considered to be a part of normal intergovernmental arrangements for which means of consultation are already available between the departments and agencies concerned. It is suggested, however, that consideration of such problems should be started at an early date following a disaster.

3. The guidelines do not refer to post-disaster assistance by government to large businesses and industry whose continued operation is vital to the economy of a community. It is recognized that there may be occasions when such assistance is warranted. A special study should be made for each such situation.

4. These guidelines are meant for application to all types of disasters and to varying circumstances across the country. They have been developed, therefore, using general terms accompanied by examples of intent where necessary. It should not be construed that the omission of any item or contingency means that it need not be considered at the time of a disaster. Each event will require an analysis of its own special requirements and government policy to deal with them.

5. The paper is divided into 3 parts - Categories of Eligible Costs, Policy Guidance and Procedures for Damage Assessment and Cost Estimation.

CATEGORIES OF ELIGIBLE COSTS

6. The Immediate Disaster Period. Eligible costs would be those related to:

(a) the rescue, transportation, emergency health arrangements and emergency feeding, shelter, clothing and transportation for persons, shelter and feeding for livestock, including the provision and restoration of facilities used for those purposes;

(b) measures taken on orders of the proper authorities to reduce the extent of damage by the removal of valuable chattels and assets and hazardous materials from the area at immediate risk, including the provision of storage space and transportation costs;

(c) the determination of the area and containment of the extent of the disaster, including emergency provision of essential community services, equipment, material and labour for protective works for individual protection and that of publicly owned institutions and utilities;

(d) the provision of emergency medical care to casualties of the disaster, or any resulting epidemic, and the transportation of such casualties from an apprehended disaster area, or of regular patients to make way for casualties, and of their return following the disaster;

(e) special security measures;

(f) special communications facilities;

(g) emergency control headquarters;

(h) special registration and inquiry services.

7. Post Disaster Assistance for Individuals. Eligible costs may include:

(a) restoration or replacement of or repairs to immovable real property, for any normally occupied dwelling place, appurtenant buildings and farm buildings and items essential to a farm business, where such dwelling place is used entirely for living accommodation, or partly for living accommodation, and the earning of livelihood by a member or members of the family unit;

(b) restoration or replacement or repairs to chattels, furnishings and clothing of an essential nature as these may be determined for each disaster (e.g., stoves, refrigerators, beds, heavy winter clothing);

(c) assistance in the restoration of small businesses where the owner's livelihood has been destroyed. This could include compensation for land gouging and serious topsoil removal where a farm operation is seriously affected;

(d) costs of damage inspection and appraisal and administrative assistance excluding those incurred by permanent staff of government departments.

8. Post Disaster Assistance in the Public Sector. Eligible costs *may* include:

(a) Clearance of debris and wreckage. Examples are:

(i) Channels and streams as necessary;

(ii) intake and outfall of sewer and storm drains to permit adequate functioning of the systems;

(iii) water supply reservoirs as necessary;

(iv) removal of buildings which constitute a definite threat to public safety;

(v) removal of trees and limbs if public safety is endangered.

(b) Protective health and sanitation facilities.

(c) Repairs to existing streets, roads and bridges, wharves and docks.

(d) Repairs to dikes, levees and drainage facilities including flood control and irrigation systems including removal of emergency works and restoration of their sites to pre-disaster condition.

(e) Repairs to government and public buildings and their related equipment. These would include such facilities as schools, hospitals, public libraries, penal and welfare institutions, police and fire stations, public office buildings and public recreational facilities such as bathing beaches, zoos and parks.

(f) Repairs to publicly-owned sewer and water utilities would be eligible. Crown corporations except those supplying sewer and water services, would be ineligible.

(g) Costs of inspection and appraisal, and where required planning and design, to determine costs of restoration or replacement excluding those incurred by permanent staff or government agencies.

POLICY GUIDANCE

9. Geographic Limitation. Eligibility will be limited to damage in defined area(s) mutually agreed to by the governments which may be involved in cost sharing.

10. Amount of Claims. Claims may not exceed the estimate of cost required to restore an item or facility to its immediate pre-disaster condition.

11. The cost of permanent repair or replacement of private property or public facilities to higher than pre-disaster standards may be included in an amount no greater than that estimated to be required for the repair or replacement to their immediate pre-disaster condition.

12. Assistance to the reconstruction of private property in disaster-prone areas should only be given once, unless effective action to avoid recurrence by the individual was not practical.

13. Eligible costs shall not include those:

(a) which are recoverable at law or insurance;

(b) which are of a class or kind for which provision is made in whole or in part under any other government program;

(c) for which assistance was previously made available to prevent the disaster;

(d) which are an ordinary or normal risk of any trade, calling or enterprise;

(e) which cannot be considered essential to the restoration of an individual to his home or livelihood or the reconstruction of essential community services. Examples of non-essential items might be summer cottages, non-essential roads and bridges, trailers, certain chattels, landscaping, fences and pleasure items;

(f) for the restoration of real property owned by any private organization or business concern except as are normally engaged in the provision of accommodation required in the emergency;

(g) which can be considered normal operating expenses of the government department or agency concerned and including maintenance budgets;

(h) such as retail sales taxes.

14. In determining the levels and types of costs for which assistance is to be made available, certain factors should be borne in mind such as:

(a) the responsibility of any individual or organization to take reasonable precautions if time was available;

(b) the response made by an individual to any warnings or instructions issued by the appropriate authorities to protect himself and his property;

(c) the availability of insurance coverage at reasonable rates.

15. Immediate Disaster Period. Expenditures in this period will be concerned with the survival of the public and protection of property. It will be difficult to plan a level of expenditures. Speed may be essential, particularly if there is no warning period available. It may be necessary to pay overtime rates for wages and rentals. As far as practicable local legislation, regulations and practises should be followed.

16. An attempt must be made to define a warning period and an emergency period including a stabilization phase during which disaster effects are still paramount but beginning to turn into a "rehabilitation phase".

17. An allocation of responsibility for certification of claims and expenditures should be made for each category of eligible expenses so that audit staffs can function smoothly.

18. Post Disaster Assistance for Individuals

(a) Government policy for financial assistance must be prepared for each event and communicated as soon as possible to the public together with the administrative arrangements for handling claims.

(b) A suitable formula for the level of financial assistance would be a political decision taken at the time of the disaster based on an assessment of total loss. It might consist of various maximum levels of assistance, e.g., one for homes, another for out-buildings and a third for small businesses.

A special level might be necessary to deal with complete demolition of buildings as distinct from those requiring modest repairs.

(c) In settling claims a suitable basis for claims might be as follows:

(i) appraised value of real property (derived from assessment rolls);

(ii) appraised value of essential goods and chattels (based on a list of eligible items and unit values);

(iii) restoration of property to pre-disaster functional standard where an assessment of values is not practical.

(d) All contested claims should be subject to review by a special non-governmental board of appeal.

(e) An expiry date for receipt of claims for damages should be set.

19. Post Disaster Assistance in the Public Sector

(a) Construction standards should adhere to the prevailing codes in the area, and to those approved by the participating agencies.

(b) Only in exceptional circumstances should standard tendering practices and wage rates for the reconstruction and restoration programs in the post-disaster period differ from normal approved procedures and policies of the participating agencies.

(c) A definite expiry date for receipt of claims for damage should be set.

DAMAGE ASSESSMENT AND COST ESTIMATION PROCEDURES

20. In some cases the costs of dealing with the disaster and rehabilitation are beyond the capability of the individual and/or the local government to pay. In these cases the provincial and possibly the federal government may be called on for financial assistance.

21. In order that the governments concerned can be in a position to act quickly on such a request, it is essential that a reasonably accurate estimate of the probable costs be made as soon as possible following the disaster. This is true whether or not damage and restoration costs are to be shared between governments.

22. Inspection teams, either from both levels of governments or from one government acting with the concurrence of the other, will be required to examine the sites where damage occured to provide a preliminary estimate of costs. At a later stage, appraisal teams will be required to determine a final estimate of costs concerned with the categories which have been authorized for assistance.

23. It is essential that, in view of the various time frames, i.e. before, during and post-disaster, and the number of specialists involved, i.e., inspectors, appraisers, etc., some form of a coordinating agency be established.

24. An additional role for such a coordinating agency in each province would be to make sure that each department and agency is aware of its own responsibilities in a disaster situation.

ORGANIZATION

25. Within each province there will be:

(a) a coordinating agency with composition and role along the lines set out in Annex "A" for federal provincial;relations;

(b) joint inspection teams and appraisers which should be organized along the lines set out in Annexes "B" and "C".

ANNEX "A"

COORDINATING AGENCY

COMPOSITION

1. The coordinating agency in each province will be chaired jointly by the Canada EMO Regional Director and an official appointed by the responsible provincial authority and will include representatives from all federal and provincial departments concerned.

RESPONSIBILITIES

2. The agency will be responsible for:

(a) Organizing a team of damage inspectors (Annex "B").

(b) Identifying the appraisal skills required and arranging for appraisers when required.

(c) Briefing the inspection teams and appraisers when a disaster occurs.

(d) Making available during and after the event, display information giving the scope and nature of the disaster and initiating visits of inspection teams and appraisers as soon as possible.

(e) Consolidating inspection and appraisal reports.

(f) Obtaining the costs of immediate measures from the responsible departments and agencies.

(g) Producing an interim report indicating:

  (i) immediate measures cost

  (ii) overall estimate of damage

  (iii) damage area limits

  (iv) damage claims - public and private sectors

  (v) other costs

This report will form the basis for a request for financial assistance.

(h) Arranging for provincial finance staff to meet with representatives from the Department of Supply and Services (Audit Services) to draft procedures acceptable to both so as to expedite audit of expenditures.

ANNEX "B"

INSPECTION TEAMS

COMPOSITION

1. An inspection team may consist of representatives from federal and provincial departments and agencies having responsibility and/or interest in disaster damage. Its composition would differ from province to province and for various types of disasters.

ROLE OF INSPECTION TEAM

2. The principal role of the inspection team is to provide a reasonably accurate estimate of damage as soon as possible after the disaster. Inspection teams will be required to provide estimates in all three categories of costs.

PROCEDURES

3. The inspection team would:

(a) Attend briefings on the disaster by the Coordinating Agency.

(b) Visit damaged areas and prepare preliminary estimates of costs.

(c) Submit report to Coordinating Agency as soon as possible including definition of damaged areas.

ANNEX "C"

DAMAGE APPRAISERS

1. There is a need for specialists to appraise damage costs for a wide variety of structures, chattels, communications and utility systems.

ROLE OF APPRAISERS

2. The principal role of the appraisers will be to evaluate damage costs in the public and the private sectors as soon as possible after the disaster.

PROCEDURES

3. The appraisers would:

(a) Attend briefings on the disaster by the Coordinating Agency.

(b) Visit all damaged areas and evaluate damage costs.

(c) Relate damage claims to appropriate criteria.

(d) Report to the Coordinating Agency submitting certified appraisals.

CCMS No. 2

MANITOBA FLOOD INFORMATION

ROLES OF GOVERNMENT, UNIVERSITIES, INDUSTRY AND VOLUNTARY ORGANIZATIONS

Introduction

1. As floods can affect almost any part of a country and because of their potentially devestating effects on both the public and private sectors of the economy, advantage must be taken of all available capabilities for flood mitigation.

Organization

2. Following the advent of nuclear weapons, Canada, as did all NATO countries, developed civil emergency planning machinery as an essential part of its overall defence concept. Governments at all three levels, federal, provincial and municipal, accepted their responsibilities for developing in peacetime, civil plans and preparations designed to ensure the nation's ability to survive and recover from any war emergency. As these civil defence/emergency measures organizations were gradually developed, their potential for planning and co-ordinating all efforts at combating peacetime disasters was also realized and governments at all three levels accepted their responsibilities in this field as well.

3. Except for the statutory responsibility of some federal and provincial departments and agencies in a few well defined areas, the organization in Canada for flood mitigation is based on the emergency measures organization at each level of government. This includes the co-ordination of the activities of government departments and agencies, universities, industry and voluntary organizations at the appropriate government level. Because of the existing constitutional responsibilities, planning and co-ordination in the operational field rests with provincial and municipal governments with the federal government acting in a supporting rôle.

Identification of Resources

4. Many of the provinces and municipalities in Canada, particularly those prone to peacetime disasters including flooding, have formed committees under the chairmanship of their emergency measures organizations. Membership on these committees includes government departments and agencies and voluntary organizations and one of their functions is the identification of resources. In addition, the provincial

and municipal emergency measures organizations, as part of their peacetime planning for a war emergency, maintain an inventory of the resources available from industry and other sources so that this information is also available for the planning of flood fighting operations.

5. At the federal level the Canada Emergency Measures Organization, in its supporting rôle, has co-ordinated the listing of the capabilities and resources of all federal government departments and agencies both centrally and regionally in the provinces. This information is made available to provincial and municipal emergency measures organizations to enable them to identify all resources available for flood fighting operations.

Public Education

6. As indicated in the introduction to this paper, advantage must be taken of all capabilities for flood mitigation and one of these capabilities is the latent potential of the general public for providing self-help in an emergency. In Canada it is accepted that government at all levels must take the inititiative in providing public education for flood mitigation. A good example of this is the Manitoba Flood Information pamphlet prepared and distributed by the Manitoba Emergency Measures Organization, which is attached.

Past Disaster Response

7. Prior to the development of civil emergency planning machinery in Canada most governments were unable to co-ordinate and control large scale flood fighting operations. The usual response was for the government concerned to request the assistance of the manpower and resources of the Department of National Defence, even to the extent, in some cases, of requesting the Department of National Defence to take over co-ordination and control of flood fighting operations. With the development of the various emergency measures organizations, provincial and municipal governments developed a capability for preparing flood fighting plans and for co-ordinating and controlling flood fighting operations, and have now accepted their rôle in this field.

8. The response of the federal government in past flood fighting operations has been to make available the resources of all the federal government departments and agencies and to provide financial assistance after the disaster. These activities are both co-ordinated by the Canada Emergency Measures Organization either through the Regional Offices or centrally.

9. The rôle of universities in the past has been in the field of operations research. The Canada Emergency Measures Organization sponsors a fellowship at the Disaster Research Centre of Ohio State University and immediately following any major disaster, including floods, a research team is provided, at the request of Canada Emergency Measures Organization, to investigate and report on the organizational and operational aspects of the response to the disaster.

10. In the past, industry and voluntary organizations have volunteered the use of their resources in flood fighting operations. The co-ordination of these resources is carried out by the various emergency measures organizations both in the preparation of flood fighting plans and in actual flood fighting operations.

Possible Future Contribution

11. Possible future contributions are considered to be:

(a) Government:

  (1) Continued development of plans for flood fighting operations.

  (2) Development of permanent measures to mitigate flood hazards.

(b) Universities:

Research into disaster organizations and operations and into permanent measures for flood mitigation.

POLYETHYLENE CAN PROTECT DWELLINGS

Polyethylene has moved into the flood protection program for Manitobans.

Manitoba dyking engineers suggest that individual citizens could do much to protect their own homes - by wrapping them in a polyethylene barrier.

The method has been tried in flood areas of the United States with considerable success.

This protective system is recommended principally for homes which are outside any primary and secondary dyking system - where water is expected to rise above the level of the first floor. It is not considered necessary if only the basement is likely to be flooded.

In short form: a roll of polyethylene is wrapped around the outside of the house, secured at joins by nailing strips, and anchored at the bottom with sand bags. The polyethene sheeting, bags and sand are provided by the Manitoba Government for this purpose and are distributed as required through municipal channels.

Engineers recommend use of 6-mil polyethylene in 10-foot widths. These rolls come in 100-foot lineal length. The number of rolls needed can be determined by the outside dimensions of the individual home.

The best way to determine the width of the polyethylene required is to decided how far up the side of your dwelling you want protection - based on forecast water levels in your area. Allow a further three feet for proper sand-bagged anchoring of the polyethylene strip.

Here is the step-by-step method:

(1) Remove valuables from basement, disconnect power and gas, and remove all electric motors.

(2) Plug basement outlets - sewer drains, sinks, toilet bowls. Don't forget possible laundry outlet to sewer. Sewer outlets must be plugged below the weeping tile drains, in the sewer trap. A suitable plug can be improvised from a linseed bag. These plugs should be braced additionally with sand bags, or with a brace to floor joists.

(3) Relocate all home furnishings above the predicted level of the flood waters.

(4) Flood basement with clean water, using the outside tap through a basement window opening, bringing the water to the level of the basement window casement.

(5) Board all windows, doors and other openings (e.g. milk chutes).

(6) OPTIONAL: For further protection against outside water pressure, the house walls may be braced from the inside. This is done by nailing a two-by-six inch "waler" - that is a strip of planking, about three feet up from the floor - around the inside walls. This will be held in place by two-by-four inch braces, each three feet apart, anchored at the base by sand bags, and a wood block.

(7) Apply the polyethylene barrier LOOSELY to the exterior surface of the house, starting above the expected flood level. Allow 3 feet for anchoring. Spread the extra 3 feet of polyethylene on the ground. Place sand bags around the house against the polyethylene, about ten bags in height.

(8) At the base, lay another row of sand bags, double polyethylene back over these bags and lay a row of bags over the polyethylene to secure it. (See diagram.)

(9) Where it is necessary to start a new roll of polyethylene, allow a two-foot overlap. Make an S-shaped fold with the two overlapping ends, and secure with a vertical nailing strip. (See diagram.)

If this protective method is used, regular checks should be made of the home to ensure that the barrier has not been pierced, and that the sand bag barrier has not been disturbed.

This method is not recommended where the predicted level of the flood extends more than four feet over the level of the water in the basement.

NOTES:

1. If the basement is not filled with water, there is a danger of the foundation collapsing from outside water pressure.
2. Remember. Once the dwelling is sheathed in polyethylene, it cannot be lived in. It is habitable until the final door is sealed up.
3. In case of conrete block foundation walls, this procedure must NOT be used.

SAND BAG DYKE NEEDS A "BONDING TRENCH"

Basically, a dyke requires that the sod be stripped from the ground, and that a "bonding trench" - one sack deep and two sacks wide - be established in the middle of the proposed dyke.

The dyke must be three times as wide as it is high. If, for example, the dyke has to be raised three feet the base width should be nine feet.

The sand bags are to be only half full. The bottom layer of bags on the dyke will run parallel to the river, with the second layer crosswise. The third layer is parallel, the fourth crosswise and so on, in alternate fashion. Each succeeding layer is set back the width of half a sand bag, both on the river side and the land side of the dyke, giving it a step-like appearance.

It is not necessary to tie the sacks. The top, or unfilled part of the sack is stretched lengthwise and the next sand bag is laid on top of it. The method is known as "lapping".

Sand bags are to be tamped firmly in place.

It's a good idea to have extra sand bags on hand to strengthen any weak spots as the water rises.

GENERAL PRECAUTIONS BY HOUSEHOLDERS

It should not be necessary to restrict the use of water in Greater Winnipeg during a flood, according to metropolitan waterworks engineers.

However, where eavestroughs are connected to house sewers, the downspouts should be disconnected in order to relieve overloading of the sewers during a heavy rain.

If eavestroughs are disconnected, the householder should arrange for them to discharge rain water on the ground at least four feet from foundations.

The following additional precautions are also noted:

Chemicals, such as weed killers, insecticides, etc., should be removed well before flooding occurs to prevent serious water pollution, fire or corrosion.

Buoyant products should not be left in basement areas. Pressure on building structures may result from these articles riding on flood waters.

If there is danger of the sewer backing up into a basement, a patent ball float device or a bag of linseed should be installed as a plug in the catch basin. This must be installed below the weeping tile connections, in the catch basin trap. As a further precaution, this plug should be held in place with a wood brace to the ground floor joists.

If you are plugging your sewer outlet, a similar action is needed for any basement toilet. The toilet bowl should be removed and the sewer connection plugged with a tightly fitting wood plug or a bag of linseed.

Householders needing assistance in these matters should call a plumber.

SHUT OFF ELECTRICITY IF FLOODING IMMINENT

Electrical power should be shut off to any premises in immediate danger of flooding, Manitoba Hydro advises. In a series of precautions issued for Hydro customers, the utility said householders should open the main service switch in urban homes, or the yard switch on farms.

However, in no circumstances should an individual enter a flooded room or basement where the hydro is still turned on.

In opening any switch, if conditions are wet, householders should stand on a dry board and use a dry stick to open the switch lever.

The following additional precautions were noted:

In the areas south of Winnipeg, there is a possibility of the river level rising to the point where clearance under energized wires could create a hazard. All boat operators should be extremely cautious.

In flood threatened areas, in order to minimize the expense and time delay of resuming normal living following an actual flood, customers are advised to take the following precautions:

Electric motors and controls should be removed. If a motor is flooded, no attempt should be made to apply power until a complete inspection and overhaul is done.

Thermally insulated appliances, which include complete water heaters, refrigerators, freezers, and ranges, should be removed. If flooded, all insulation would require changing.

NOTE: With the present cost of parts and labor, repairs to flooded thermally-insulated appliances would not be practicable. Replacement would be necessary in the great majority of cases.

Baseboard heaters and portable heaters should be removed. It is doubtful if these could be made safe if flooded.

Portable electric appliances and tools should be removed. If flooded, no attempt should be made to use them until overhauled.

Radios and televisions should be removed. These constitute a definite hazard if flooded. It is presumable that repairs would not be practicable.

All electric wiring in homes, barns, and other buildings which have been partially or fully covered by flood waters is required to be inspected before again being put into service.

Manitoba Hydro will attempt to keep electric service available to those individuals and institutions requiring service as long as it is physically and humanly possible.

PROTECTIVE MEASURES FOR GAS-FIRED FURNACES

The Department of Labour notes that gas-fired equipment would be damaged if subjected to flood waters. If premises are in danger of flooding, citizens should have their heating contractor remove motors, burners, controls, etc.

However, if the services of a qualified person are not available the procedure set out below should be followed.

Do not attempt any work until the gas supply to your premises has been shut off.

(1) Shut off electrical supply to equipment and leave it off.

(2) Shut the gas appliance valve off by turning square cock 90°. This valve is usually located where the piping drops down to the appliance.

(3) On warm air furnaces remove fan motor and, if possible, the fan.

(4) On hot water boilers equipped with a circulating pump, remove pump motor. Do NOT attempt to remove the pump itself from the piping system.

(5) If gas fired clothes dryers, ranges or other appliances are moved, it is essential that the appliance valve be shut off as in No. 2 and also the gas piping outlet be plugged or capped with a proper pipe fitting. This is necessary to ensure that water does not enter the gas piping system.

(6) Do NOT drain the water from hot water tanks.

Remember - leave the electrical supply off - The disconnected wires could cause an electrocution.

N.B. AFTER WATER HAS SUBSIDED, DO NOT ATTEMPT TO PLACE GAS EQUIPMENT BACK INTO SERVICE YOURSELF. THIS WORK MUST BE DONE BY A LICENSED GAS FITTER.

PRECAUTIONARY MEASURES FOR OIL-FIRED EQUIPMENT

Citizens should take precautionary measures to protect oil-fired equipment against flood damage, the Department of Labour says.

To avoid damage, motors, burners, controls, etc., should be removed by a heating contractor. However, if the services of a qualified person are not available, the following procedure should be carried out:

(1) Shut off electrical supply to equipment and leave it off.

(2) Remove oil burner motor and ignition transformer, or alternatively, remove complete burner unit. If the complete burner unit is removed, plug copper oil supply line to make line water-tight.

(3) On forced warm air furnaces, remove fan motor and, if possible, the fan.

(4) On hot water boilers equipped with a circulating pump, remove pump motor. Do NOT attempt to remove the pump itself from the piping system.

(5) If possible, remove stack control, high limit and fan controls.

(6) If the water level is higher than the top of the oil tank, the tank will float; to prevent this:

   (a) Remove oil level gauge and plug opening with a proper threaded plug (usually 1½" IPS plug).

   (b) Have tank filled with oil.

   (c) Place at least 300 lbs. of weight on top of tank. Sand bags are ideal for this. (If tank was only one-half filled with oil, about 1,200 lbs. of weight would be required.)

   (d) Shut off oil outlet valve at bottom of tank.

Remember - leave the electrical supply off - The disconnected wires could cause an electrocution.

N.B. AFTER THE WATER HAS SUBSIDED, DO NOT ATTEMPT TO PLACE OIL BURNER UNIT BACK INTO SERVICE YOURSELF. THIS WORK MUST BE DONE BY A LICENSED OIL BURNER INSTALLER.

TIE DOWN PROPANE TANKS IN AREAS OF FLOODING

Propane tanks will float, even when full of propane, the Department of Labour has cautioned. They should, therefore, be anchored to keep them from floating away. The following routine has been suggested:

(1) Turn off the valve on the propane tank.

(2) Disconnect the tubing to the tank and plug it.

(3) Tie a cable or logging chain around the tank and anchor the other end to a pole, building, or other substantial structure to prevent the tank from floating away.

(4) When the water has subsided, call your propane supplier to have the tank placed back on its supports and connected to the necessary appliances after they have been placed in working condition by a licensed gas fitter.

PROTECTION FOR FARM MACHINERY

Farmers are advised to move equipment which is in danger of being flooded to high ground, the Department of Agriculture says. Most farmers will know of high ground which may be used for this purpose. If not, flood control headquarters at Morris and Emerson can provide information on where machinery and equipment might be stored.

If it becomes impossible to move the equipment it should be sealed as much as possible.

Equipment with Gas or Diesel Motors

Start engine, run for 10 to 15 minutes. Drain oil and fill with SAE 30, MS or DG. Run for another 10 to 15 minutes to get new oil to all working parts.

Remove spark plugs, put one or two tablespoons of SAE 30, MS or DG oil in each cylinder and replace plugs. Remove the starter, generator, carburetor and coil.

Seal all openings, including those of the distributor, oil filler, air intake and exhaust with polyethylene, tied securely, or by cork or a wad of polyethylene packed into the opening.

Transmissions are fairly well sealed against water, but if there is an air vent in the filler plug, it should be covered with a multi-purpose grease. Clutch plates should be released.

Farm Machinery

This equipment should have a good grease job before approach of any flood waters. Make certain the grease contains a rust inhibitor.

All exposed wear parts should be coated with multi-purpose grease, and drive chains swabbed with SAE 30, MS or DG oil.

Sealed bearings, such as front wheels of tractors, etc., should be removed after the flood, cleaned and repacked.

In pre-flood greasing, care should be taken not to overfill bearings, forcing out the seals.

CHECKLIST FOR BUSINESSMEN

A checklist containing suggestions for the protection of business premises threatened by flood has been prepared by the Department of Industry and Commerce.

Copies of this checklist are available to businessmen on request to their local Chamber of Commerce, from the Manitoba Chamber and from municipal offices.

Additional copies will be on hand at the provincial and local flood control headquarters.

The checklist provides a plan of action for businessmen on such things as electrical precautions, heating systems, documents, stock, sewer and water systems, machinery and equipment.

FLOOD RECEPTION CENTRES ESTABLISHED

For people whose homes are in flooded or flood-threatened areas, and who need assistance, reception centres have been established to provide a registration and information service, emergency shelter, lodging, feeding and clothing.

Volunteer agencies, such as the Red Cross, Salvation Army, and the Community Welfare Planning Council, will provide assistance where necessary at these centres.

Here is a list of reception centres, currently established, or ready to go into operation:

1. ALTONA

   Braun Drugs, Main Street, Altona,
   Telephone 324-5347

2. CARMAN

   Memorial Hall Basement, 12 Walnut St., Carman.
   Telephone SHERWOOD 5-2479.

3. MORDEN

   Municipal Hall, Morden, Telephone 822-4242
   Town Office number 822-4420.

4. STEINBACH

   Curling Rink Waiting Rooms. Telephone DAVIS 6-3676 and DAVIS 6-3811.

5. ST. PIERRE

   Recreation Centre, Telephone numbers 116 and 214.

6. METROPOLITAN WINNIPEG 1

   1. Former Safeway Store, Pembina near No. 3 Highway (Oakenwald Ave.), Fort Garry.
   2. Notre Dame School Auditorium, Rue Cathedrale at Rue St. Jean Baptiste.

HINTS FOR PEOPLE LEAVING THEIR HOMES

1. Ensure that each member of the family has warm clothing, including waterproof outer garment.
2. Warm, waterproof footwear.
3. At least one blanket per person, rolled in a plastic sheet if possible.
4. Ensure each member of the family carried identification, particularly young children. Name tags on clothes, wallet cards or wrist bands are all suitable.
5. Personal and family documents should be carried in a plastic envelope or wallet.
6. Essential medicines, particularly for those under doctor's care. Have at least two weeks supply on hand.
7. Infant care items, ensure a good supply of food, bottles, diapers, etc.
8. Hand towels (one per person), soap and personal toiletry items.
9. Have a transistor radio with you with spare batteries. Also a flashlight and spare batteries.

IMMUNIZING AGENTS ARE STOCK-PILED

Health officials advise that a stock-pile of gamma globulin, vaccine, sera, and some antibiotics has been established for use in Manitoba during the flood period if required.

According to Dr. E. Snell, Director of Preventive Medical Services, diseases which are most likely to present a hazard during a flood situation are those spread by water. These include Typhoid Fever, Dysentery, Poliomyelitis and Infectious Hepatitis.

Most people in the province have been well immunized against poliomyelitis, consequently the majority of the population will be immune to this disease. There are no effective vaccines available to combat Dysentery or Infectious Hepatitis, but supplies of gamma globulin are available for administration to contacts of Infectious Hepatitis if the need arises.

Mass immunization with Typhoid vaccine has sometimes been carried out prior to potential flood threats, but following careful consideration with respect to the present circumstances in Manitoba, Health Department officials do not recommend wide-spread Typhoid immunization.

Prevention of infections resulting from flood conditions will largely depend on the maintenance as far as possible of a satisfactory water supply for domestic purposes and good sewage disposal methods.

FLOOD WATERS HAZARD TO DRINKING WATER

Flood waters, polluted with sewage and other contaminants, could present a threat to the health of people in flooded areas through contamination of private water supplies (wells).

Health officials warned that any change of taste or odour in well-water during periods of high water is an indication of likely contamination even though no surface flooding is visible. Movement of underground water may bring in contaminated water to private water supplies. Officials stress that treatment of drinking water should be undertaken immediately if any changes are noticed.

Two methods of water purification are recommended:

(1) Water that is brought to a boil and allowed to cool is considered safe for drinking. Aerating boiled water will remove the flat taste. To accomplish this simply swish water around in a closed jar.

(2) Chlorination of water with bleaching compound such as javex is commonly recommended for water purification.

Water can be chlorinated by the addition of two drops or more of a bleaching agent in one gallon of water. Following treatment the bleaching agent should be allowed to react for fifteen minutes before the water is used. After a fifteen minute treatment period a definite chlorine taste should be noticed in the water. If not, the treatment procedure should be repeated. Overdoses of chlorine are not likely to occur from repeat treatments, as no harmful effects result from water containing one hundred or more times the amount of chlorine used in the prescribed treatment procedure. This means that treatment could be repeated many times without creating a health hazard. All water with a definite chlorine taste after a fifteen minute treatment period can be considered safe for drinking purposes.

With respect to municipal water supplies, the Health Department advises that public health engineers will be stationed at each municipal water treatment plant in potential flood areas. Immediate plans are underway for continuous operation of water treatment and sewerage facilities at Morris and Emerson. Anyone on these water systems will receive water that is safe for drinking purposes.

Detailed information on water purification is available from the Environmental Sanitation Branch of the Manitoba Department of Health, Room 305, Norquay Building, Winnipeg - Telephone WH 6-7726.

PROTECT FOODS FROM FLOOD DAMAGE

Preventive action to ensure that foods do not become damaged or contaminated by flood waters is advised by health officials.

They recommend that in both private homes and commercial establishments food products stored below ground level be raised at least to the main floor level. Precaution should also be taken to ensure that alternate storage areas are dry.

With respect to the safety of perishable food supplies, precautions should be taken to ensure that refrigerators and frozen food storage units are located where flooding is not likely to occur. As the operation of refrigeration units is solely dependent on electricity, perishable foods and frozen products should be kept to a minimum if there is a possibility that the supply of electricity may be cut off.

To avoid the health hazard of eating food that has been contaminated with flood waters, health officials recommend that:

- Non-liquid foods, including dried fruits, cereals, flour, shortenings, spices, packaged goods, meats (fresh and cured), should be destroyed.
- Canned goods should be destroyed where the seal is damaged or where contents show signs of seepage.
- Bottled food products including home preserves should be destroyed.
- Bottled drinks should be destroyed. Washing the outside of bottles does not make a bottled drink safe for use as there may be contamination under the edge of the cap. Also, canned drinks should be destroyed if the seal is damaged or if contents show signs of seepage.
- All contaminated leafy vegetables should be destroyed, although root vegetables may be used if they are sound, thoroughly washed and cooked.
- All contaminated utensils and dishes should be thoroughly washed and sterilized by boiling or immersing in a suitable sterilizing solution for five minutes.

Actually, any food that has been exposed to possible contamination by flood waters should probably be destroyed to eliminate any danger to health.

Advice and assistance concerning food contamination is available from the health department's food control personnel. Any inquiries should be made directly to the Local Flood Control Headquarters where they will be dealt with on an emergency basis.

FLOOD CLEAN-UP PROCEDURES

Flood waters are likely to be polluted with sewage and other contaminants and thus they present a threat to the health of all people in a flooded area. They details outlined below are recommended as reasonable and practical but if problems arise which are not covered here you should contact your local Health Agency for assistance.

Disinfectants - Two of the most readily available disinfectants are chloride of lime (or chlorinated lime) and liquid bleach (such as "Javex"). To make a disinfecting solution with chloride of lime add half a pound to a pail and mix thoroughly with a small amount of cold water to form a smooth paste. Then fill the pail about three-quarters full with water, mix thoroughly and allow to stand until the lime settles out. The clear liquid contains the useful chlorine.

Other disinfectants are available and the directions for use should be followed.

Flooded Basements - All water in a flooded basement should be disinfected every three or four days if the home is occupied. Use two pails of the chloride of lime preparation or four pints of liquid bleach.

Once the water has left the basement remove all debris and mud using hoses, buckets of water or rough scrubbing. Encourage drying by opening all windows and, if possible, adding heat. Scrub all surfaces with a disinfecting solution - rough surfaces may be sprayed with a small hand sprayer. Crawl spaces under basementless homes may be treated by sprinkling chloride of lime on the ground. Use disinfecting solutions with care on metal surfaces since prolonged exposure may cause rusting.

Furnishings - Furnishings which may be harmed by disinfecting solutions should be thoroughly cleaned with soap and water. Upholstered furniture should be taken outside to dry, preferably in the sunlight.

General Clean-Up - Attention should be given to the removal of flood-borne material from yards. All material that will burn should be raked up and burnt. Other refuse should be collected into convenient piles for removal by the local garbage pickup or scavenging system. Particular effort should be made to remove filth which might serve as a breeding place for flies.

Water Supply - All wells should be treated with a disinfecting solution such as one pail of the chloride of lime preparation or two pints of liquid bleach. The resulting chlorine taste is not harmful and will disappear in a few days. As soon as possible have the local health agency test the well water for bacteriological contamination or arrange to get a sampling bottle so that you may submit a sample for analysis.

Surface water may be treated by bringing to a boil and allowing to cool before use.

Pit Privies - As long as water remains in the pit add one pound of chloride of lime each week to each pit. This will help protect local water supplies.

FLOOD CONTROL IN CANADA

by T.E. Weber (Canada)

Canada as a Nation is endowed with an abundance of fresh water lakes and streams. It was these waters that provided the highways on which the early explorers and settlers travelled to explore and settle in many of the regions of Canada. The history of Canada's development records the occurrence of floods as great or greater than those of recent decades, The development of the lands for agriculture and the expansion of urban settlements into the flood plains over the years has resulted in an increased need for flood control measures.

Under the British North America Act which created the Canadian Nation, the control of natural resources was invested in the provinces. Each province, therefore, has developed an administration framework for the control and regulations of water, dictated by the needs of that particular area. The Federal Government assumes the role of a co-ordinating agency and provides both technical and financial assistance under Federal Legislation or through special cost-sharing agreements. The Federal Government also provides liaison with other countries on matters of oommon concern in respect to water.

In 1909 the International Boundary Waters Convention was signed between Canada and the United States and under this treaty the International Joint Commission composed of a Canadian Chairman and two Canadian members with United States' counterparts was created to deal with matters respecting trans-boundary waters. The International Joint Commission does not have a staff of engineering technicians under their jurisdiction but depends on the various water agencies in both countries to supply the engineering information for preparation of reports. The Commission, following the review of these reports from the various boards and Committees, makes recommendations to the Governments of the two countries following which agreements or treaties are consummated in respect to the control and use of international waters.

There are four pieces of Federal Legislation which play an important part in water conservation and flood control programs in Canada. The Prairie Farm Rehabilitation Act which set up the Prairie Farm Rehabilitation Administration (P.F.R.A.) in 1935 under the Department of Agriculture; the Canada Water Conservation Assistance Act, administered by the Department of Northern Affairs and Natural Resources; the Agricultural Rehabilitation and Development Act (ARDA) which was passed in 1961, and the Maritime Marshlands Rehabilitation Act passed in 1948 which created the Maritime Marshlands Rehabilitation Administration under the Department of Agriculture.

The P.F.R.A. provides technical and financial assistance for the construction of water conservation works in the three Prairie Provinces. In addition to the provision of assistance, the P.F.R.A. carries out, at a 100% Federal cost, major control works related to the conservation of soil and water in Western Canada. Under the Canada Water Conservation Assistance Act, the Federal Governemnt may provide assistance for the construction of water conservation works in all parts of Canada. Under the terms of the Legislation, a province may receive 37½% of the total cost of approved projects.

The ARDA Act of 1961 is a comprehensive act to provide assistance both technical and financial to the provinces for the improvement in the use of marginal lands, for developing new opportunities for increased income and employment in agricultural areas and for projects for the development and conservation of soil and water.

The Maritime Marshlands Rehabilitation Act provided assistance to the Maritime Provinces to reclaim tidal marsh lands. Since 1961 the Maritime Marshlands Administration has been providing technical service to the provinces for designing projects which could be implemented under the ARDA program. In 1963 the administration of this Act along with ARDA Act, passed from the Department of Agriculture to the Department of Forestry.

The major cause of flooding on the Rivers in Canada is the spring snow melt when the winter's precipitation is released in a short period as a result of a rapid rise of temperature. Flooding is also associated with ice jams in the Rivers during the spring run-off period. Ice jams occur as a result of ice pans being held up at bends, natural obstructions or bridges in the channel. This problem is very prevalent on North flowing rivers where the snows melt early in the upper part of the watershed, whereas the lower reaches are still frozen. When ice jame occur, the resultant flood is usually of short duration and has sharp peaks.

Floods which are associated with violent local storms caused by convectional flows of air occur in the summer in the Southern part of Canada. These floods affect small watersheds only and are of short duration. The flooding from this type of storm is often suffered in urban areas where storm drains are overtaxed.

Floods occurring as a result of cyclonic storms have been recorded in Canada. The most severe flood resulting from this source occurred in Ontario in 1954. Hurricane "Hazel" which swept inland from the area around New York caused catastrophic effects on the Metropolitan area around Toronto.

The various regions of Canada have developed flood control works best suited to the particular region and examples of the following methods of flood control, either singly or in combination, can be found in the various regions:

1. Reduction of peak stage by means of channel improvements.
2. Diversion of flood waters through by-pass channels.
3. Protection of flood plain areas by dykes or flood walls.
4. Reduction of peak discharges by dams and reservoirs.

In combination with the above engineering works, flood plain zoning or acquisition of flood susceptible lands has been included as part of the overall plan in some regions. In regions where watershed conservation authorities are in operation, the authorities encourage and practise good land use and reforestation as a further means of reducing flood potential in an area.

In several provinces a system of flood forecasting has been introduced on certain flood susceptible watersheds. Through this means adequate warnings of possible flooding in areas can be forecasted in advance and affords the opportunity for protective measures to be taken, thereby reducing flood damages. In the operation of flood control structures on rivers such a system of forecasting becomes a necessity to ensure the proper gate settings are maintained to render the desired protection.

In the Maritime Provinces, the flood problems have not reached such major proportions that require the construction of flood control works to reduce the damage resulting from the overflow of channels. However, in Nova Scotia, on the Musquodoboit River in Halifax County, a $500,000.00 dam and stream improvement program is proposed. The cost of this project will be shared between the Federal, Provincial and Municipal Authorities in Nova Scotia.

Flood protection works have been carried out under the Maritime Marshlands Rehabilitation Administration. The main elements of works are dams at the mouth of rivers to control tidal waters. The continual change in stream beds which is characteristic of tidal rivers is controlled and land above the dams is reclaimed for agriculture.

Two major projects completed under this program are the Annapolis River Dam which cost 2.5 million dollars and protects 4,300 acres of farm land in Nova Scotia and in New Brunswick a dam on the Tantramar River which protects 18,000 acres, as well as providing a highway crossing, at a total cost of $905,000.00.

In Central Canada, where are found the most densely populated areas, major flood problems are encountered in the watersheds bordering the Great Lakes in the Southern part of the Province of Ontario. The responsibility for the initiative of undertaking flood control works is delegated by the Province to conservation authorities. Authorities are corporate bodies and can carry out almost any type of conservation project in respect to soil and water. The Provincial Government provides a technical and financial assistance to the authorities through the Conservation Authorities Branch of the Department of Energy and Resources Management.

Due to the rapid expansion of the urban areas in this region over the past twenty years and the extensive use of agricultural lands for special crops, the need for flood control measures has been intensified. The benefits accruing from such works can justify the expenditures required for construction of dams, stream improvements and concrete lined flood channels within a densely populated area.

These circumstances have led to formation of the thirty-three conservation authorities. The Conservation Authorities Branch carries out the initial engineering studies, to lay out the preliminary program for flood control and other conservation projects in the watershed area within the boundaries of the authority area. The authorities must engage consulting engineers for the design and construction of the various works in the watershed.

The Province provides grants; up to 50% of the cost of flood control works, reforestation and purchases of land for conservation work and administration costs; up to 75% for the water supply reservoirs and preliminary engineering. Grants of 100% are paid for the management of reforested areas.

On large flood control schemes, the Government of Canada may contribute 37½% under the Canada Conservation Assistance Act. A similar grant from the Province leaves 25% to be paid by the authority through assessment on the benefitting Municipalities. In 1964, the Province of Ontario provided grants in excess of 5.5 million dollars for works under this flood control program. Ontario is the only Province which has carried out works under this Federal Act to the end of 1964.

In the Province of Quebec up to 1964, the major project under study was the flood control on the Chaudiere River. The estimated cost of the construction of three dams to protect both urban and agricultural land, was five million dollars. This program will be shared 50/50 between ARDA and the Provincial Department of Natural Resources in the Province of Quebec.

In the Prairie Provinces of Manitoba, Saskatchewan and Alberta, the emphasis is on the control of water to protect agricultural land. In Alberta and Western Saskatchewan, the control of water for the release to irrigation districts is given a high priority in provincial programs. In the field of water conservation, the P.F.R.A. has played a major role in this region of Canada.

In considering the programs in the provinces, Manitoba, lying at the lower end of the major river systems of the prairie region has a major flood control problem on the Red and Assiniboine Rivers. After the disastrous flood on the Red River in 1950, investigations carried out by the Federal Government and the Province led to the recommendation of an $85,000,000.00 three-project program for flood control on the Red and Assiniboine Rivers.

The major project is the excavation of a one hundred million cubic yard, 30 mile diversion channel to carry the flood waters of the Red River around the Metropolitan Area of Winnipeg. A diversion from the Assiniboine River at Portage la Prairie to divert a flow of 25,000 c.f.s. to Lake Manitoba and the construction of an earth dam with control works to allow regulation of the flow from a 340,000 acre-foot reservoir on the Assiniboine River near the boundary between the provinces of Manitoba and Saskatchewan. This program has a benefit cost ration of 2.73 and when completed in 1968 will protect the Metropolitan Area of Winnipeg against a flood of 169,000 c.f.s. with a frequency of return once in 161 years. There is no local or municipal contribution in these projects. The Federal Government is sharing 75% of the cost of excavation and 37½% of the remaining costs on the Red River Floodway. On the Shellmouth and Portage Diversion projects the Federal Government is assuming 50% of the cost of construction, with the engineering costs of the Portage Diversion being assumed by the Province and those on the Shellmouth by the Federal Government.

This flood control program when fully operational in 1970 will provide protection to Metropolitan Winnipeg with a population of 500,000 representing almost half the population of the Province. Along the Assiniboine River between Portage la Prairie and Winnipeg, approximately 436,000 acres of rich agricultural land will be protected, as well as urban and agricultural lands in the River Valley near Brandon. In addition to the flood control benefits, secondary benefits related to municipal water supply, irrigation and recreation will be available from the completed works.

On drainage and flood control works, for the protection of agricultural lands in the province, the Province provides technical services and grants that range from one-third to two-thirds of costs. The Municipal authorities are responsible for the construction and operation of the works. On major channels the province assumes 100% of the cost except where the project is under the ARDA program when the Federal share is 50%. In respect to the maintenance, municipal authorities are responsible but do receive technical assistance as well as grants similar to that for construction. Technical services and grants are provided through the Water Control and Conservation Branch of the Department of Agriculture and Conservation.

In Manitoba, there are no conservation districts, however, drainage maintenance districts are set up to maintain the large network of drainage works within the low lands of Manitoba.

Major dam construction for water conservation is carried out 100% by the P.F.R.A. in Manitoba with the province responsible for maintenance one year after construction. These dams are constructed for water conservation purposes and agricultural benefits; flood control is usually a secondary consideration.

In Saskatchewan, the P.F.R.A. carries out the dam construction as in Manitoba. Unlike Manitoba there are conservation and development area authorities which assume 25% of the cost of flood control programs with the province assisting both financially and with technical services through the Conservation and Development Branch of the Provincial Department of Agriculture. In Saskatchewan, as in Manitoba, where possible, assistance is obtained through the ARDA program for water control works.

There are no major flood control works in the province of Saskatchewan protecting urban property and the main works constructed to data are for the protection of agricultural land due to flooding from spring freshets and summer rains.

In Alberta, the construction of flood control and drainage works have been carried out in the northern part of the province. The types of works carried out are mainly confined to channel clearing, improvement in alignment and dyking. The investigations, design and construction supervision are provided by the province through the Water Resources Branch of the Department of Agriculture. The costs are usually shared on a 50/50 basis between the Province and the local authorities.

The Pacific region, due to the Rocky Mountains and the narrow band of agricultural land along the Pacific Ocean and in the other river valleys, have problems quite different to those of the other regions of Canada. Dyking for the protection of lands from flooding due to the rapid run-off during the spring freshets and tidal waters commenced in the second half of the last century. The administration of the dyking and control works is handled in the majority of the areas by Dyking and Drainage Districts although in the early construction, private capital was used in many areas.

The major area of flood control is in the lower Fraser River Valley where 190,000 acres of agricultural and 5,000 acres of urban land is protected. Following the disastrous flood in 1948 under a joint Provincial and Federal program, the dyking system was completely reconstructed at a cost of 11.5 million dollars. Maintenance of the works involving 335 miles of dykes, stream improvement, diversion channels and pumping plants with a total capacity of 4,000 c.f.s., is the responsibility of the dyking districts assisted by the municipalities of the province.

There are three other major flood protection schemes in the province. The Nicomekl and the Serpentine Rivers have been dyked and controlled by two dams to protect 13,500 acres of urban land in Surrey Municipality. At Creston on the

Kootenay River, a system of flood protection works first constructed in 1892 was completely reconstructed after the 1948 flood by the Province for the dyking districts. The third is a $1,500,000.00 protection program constructed by the Federal Government and the Province to protect 10,000 acres of urban land in Pemberton from overflow of the Lillooet River.

Over the past decade there has been a noted increase in the need for flood control works both of a minor and major nature to protect both urban and agricultural lands. The important role of water as a natural resource required for the development of the economy of Canada is being given serious attention by all levels of Government, at this time. In every province, increased activity is recorded in the development of planned programs for water conservation and flood control to ensure the proper use and control of this valuable resource.

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HIGH WATER REPORTING ALONG FEDERAL WATERWAYS

Presentation by Germany

In accordance with water legislation applying in the Federal Republic of Germany, the High Water Reporting Service is a joint responsibility of the Federation and its member states (Laender). Federal competence in this field is limited to the Federal waterways which, however, include the most important waterways in the country. A list of these inland general traffic waterways under Federal jurisdiction is appended to the Federal Waterways Act (Bundeswasserstrassengesetz - BGB1. 1968, p. 188).

The Federal Water and Shipping Administration operates its high water reporting system under paragraph 35 of the Waterways Act. This includes:

(a) observation of water levels (high water reporting);

(b) dissemination of high water reports;

(c) forecasting of water levels.

High water reporting centres for major rivers are located at the headquarters of the "Wasser - und Schiffahrtsdirektionen" (Water and Shipping Directorates).

Ad (a):

Observation is carried out by means of an extensive network of water gauges which have in principle been installed according to uniform criteria. Each water gauge is equipped with a lath gauge (Lattenpegel) supplemented at important observation points by a device for registering measured values. Particularly important gauges are to an increasing extent being equipped with punched tape machines for electronic evaluation. The former practice of gauge reading by hired observers is gradually being replaced by the use of automatic answering machines and the generally adopted technique of tele-transmission from the measuring points directly to the reporting centres in the Water and Shipping Directorates.

Ad (b):

The High Water Reporting Service begins to operate as soon as a 'reportable' water level (Meldewasserstand) fixed for each gauge concerned has been exceeded. From that moment until the termination of the service's period of operation, the hydrologic agencies of the General Water and Shipping Administration are generally manned round the clock. High water reports are disseminated in accordance with so-called 'high water reporting codes' (Hochwassermeldeordnungen). The respective reporting channels between originators and recipients are routed partly over an internal telephone network of the administrative authorities concerned, and partly over the public telephone or telex system. Recipients listed in the reports include agencies responsible for warning the population, other authorities concerned, broadcasting companies, rescue and relief organisations (such as "Technisches Hilfswerk" - Technical Organisation for Disaster Control), other associations concerned, shipping companies, loading firms, storage services as well as industrial and business enterprises.

Ad (c):

In order to meet the urgent needs of cities, local authorities, ports, factories and other facilities in the event of high water, forecasts of water level trends are disseminated as early as possible in addition to the reports on water levels already occurred. This field of activity has been attracting more and more interest during the recent past. At present, empirical short-term forecasts are furnished which are based on well-computed discharge diagrams. As far as possible, however, forecasting is to be improved in order to achieve long-term forecasts with the aid of the latest techniques as well as electronic computers.

Warning messages for the North Sea and Baltic coast in case of high tide raised by storm emanate from the "Deutsche Hydrographische Institut" (German Hydrographic Institute); they are disseminated by broadcasting and transmitted by telegraph or telephone according to an established distribution schedule to recipients such as the coastal states (Laender) and the Water and Shipping Directorates. The latter, using all available data from seashore and inland gauges, reports from the German Hydrographic Institute and messages from lightships as to velocity and direction of the wind and weather conditions, inform themselves of the decisive components for the determination of the level to which the tidal wave is expected to rise. On the basis of the tidal impulse of the sea and the discharge rate of inland surface waters, they determine the probable peak level with greater accuracy and forward this information to the competent Laender authorities.

FLOODS CAUSED BY UNUSUALLY HEAVY RAINFALLS IN AREAS NOT NORMALLY EXPOSED TO SUCH DANGER
(1965: EASTERN PART OF WESTPHALIA;
1968: TOWN AREA OF SOEST;
1970: RHEIN-SIEG DISTRICT

Presentation by Germany

Floods caused by heavy rainfalls in areas not normally exposed to dangers of this kind have repeatedly occurred as a result of a sudden and unpredictable downpour of tremendous quantities of water on towns, villages and farmsteads situated in lowlands.

All these precipitations were caused by clouds gathering at low altitude which were held up by ridges of hills and discharged rainfalls of unprecedented concentration. Dammed up by obstacles, these masses of water formed flood waves of considerable velocity and high pressure.

As a rule, flood waves of this kind disrupt telecommunication landlines and traffic. They carry away masses of mud, rubble, trunks and boughs of trees, and they are capable of damaging or destroying houses, bridges, roads and the borders of watercourses. Their effect is short but devastating, and the moment of surprise makes them particularly dangerous.

Preventive measures against disasters in this order of magnitude can only be taken to a limited extent. Flood retention basins are expensive to build and may be used for purposes other than originally intended when they have been unused for years. As far as human foresight goes, they may well be an appropriate means of protection in areas pregnant with disaster, but not in areas where such natural phenomena occur at long intervals and with varying centres of gravity.

Within the range of precautionary measures, the establishment of a reliable system for warning populations and facilities likely to be endangered will therefore be of particular importance. The most suitable means to be employed for this purpose will include sirens, radio messages, mobile public address systems and helicopters equipped with electric megaphones. For those living in the immediate vicinity of the source of the flood wave, none of the means just mentioned can guarantee timely warning, because they will be surprised by the disaster and will only in exceptional cases be able to pass on the information or ask for help. On the other hand, existing warning facilities are sufficient to alert people and installations etc. at a certain distance from the source of the flood wave.

For rescuing people in danger, and in particular those living near the source of the wave, only the fire-fighting services, of all other disaster control units, are in general readily available; thanks to their widely and evenly dispersed organisation and their traditional high degree of readiness, the fire-brigades offer the best guarantee for quick assistance. Where they find access roads already blocked, the helicopter will remain the only means of rescue. The question as to whether units of the Armed Forces and of other organisations can be committed without delay will depend on the distance from the place where they are stationed and will thus be left to mere chance. As a rule, such forces will not be employed until they have to be called upon to relieve the fire-brigades and carry on the rescue work and other necessary assistance.

A decisive factor for smooth and effective action to combat surprise attacks by the forces of nature lies in the adequate education and training of the local and regional staff directing disaster control operations. This form of training must enable the staff to identify any potential source of danger and, regardless of the probability of actual occurrence, to incorporate in their disaster control plans such unambiguous regulations for warning and rescue as will make it possible even for auxiliary personnel, at night or during holidays, to initiate and carry out any necessary measures with due circumspection.

Map exercises and staff meetings should follow up the training and should lead to a review of disaster control plans in the light of technological development.

ORGANISATION AND IMPLEMENTATION OF DISASTER CONTROL IN THE FEDERAL REPUBLIC OF GERMANY

I. Under the Basic Law of the Federal Republic of Germany, disaster control is mainly a responsibility of the Federal states or Laender. Within their regional policy, disaster control falls under the heading "general protection against dangers". Thus it is essentially the responsibility of the Laender to take all the necessary precautions under their own jurisdiction in order to deal with any disaster which may occur.

On the other hand according to a resolution adopted by the Deutsche Bundestag on December 16th, 1960 the initiation of centralized relief measures by the Federation in case of internal disasters is only a subsidiary measure and may only be resorted to if, because of the extent of the disaster the resources of the responsible Land are not sufficient to cope with it, or if supra-regional aspects are predominant.

II. 1. In this case - as well as at the request of the Laender - the Federal Government can employ:

(a) The "Technische Hilfswerk" (Technical Relief Service), a Federal institution without legal capacity, comprising a Control Centre as well as regional (Laender) and local organisations. Its special function is to render technical assistance in cases of disaster or large scale calamities and to assist in maintaining control in public emergencies representing a danger to vital resources, public health, and essential communications.

With its 70,000 (approx.) trained voluntary members, the "Technische Hilfswerk" constitutes the fully equipped special disaster control organisation of the Federal Government

(b) The Bundeswehr (Federal Armed Forces) and the Bundesgrenzschutz (Federal Frontier Police) who, as part of their disaster assistance, furnish personnel, aircraft, motor-vehicles, equipment and material, shelter billets, and field kitchens for emergency feeding.

In addition, the provision of medical personnel and equipment as well as the utilization of unlitary medical resources may be required.

2. In addition, the Federal Government may in such cases at least for the time being, call upon the Luftschutzhilfsdienst (Civil Defence Service) which has been established on behalf of the Federation by the Laender and local authorities and has been equipped by the Federal Government. The Civil Defence Service is to be integrated into the Disaster Relief Service (see also Section V).

3. Furthermore, the Federation contributes to the taking of precautionary measures by permanently granting financial assistance to the central voluntary organisations such as the German Red Cross, the "Arbeiter-Samariter-Bund", "Johanniter-Unfallhilfe", and "Malteser-Hilfsdienst". These grants, inter alia, are designed to prepare general disaster relief measures. In addition, the German Red Cross with the aid of Federal funds is setting up mobile units (Hilfszug) these units being available both for disaster control and for civil defence purposes.

If the above conditions prevail, the Federal Minister of the Interior is responsible for initiating centralized relief measures. Since the Federal Government subsequently only exercises a subsidiary function, it seems appropriate in this connection also to explain the organisation of disaster control in the Laender.

III. The government of the Laender have made their own arrangements for disaster control by setting up disaster control plans or appropriate directives which are similar in their substance. The "Directives on the organisation and implementation of disaster control in the Land North Rhine-Westphalia" may serve as an example.

A) Accordingly, the following organisational pattern exists:

1. Responsibility for all measures of disaster control is in the hands of:

(a) the local communities who have the principal task of taking all measures necessary to ward off disasters (Disaster control at the local level);

(b) the Landkreise (rural districts) which take action in the case of supra-local (supra-local disaster control);

(c) finally, the Land (in particular the "Regierungsbezirke") if several districts ("Kreise") are affected (regional disaster control).

2. Under the authority of the responsible Disaster Control Centres, disaster relief services have to prevent or remedy emergencies created by disasters.

The disaster relief organisation consists of the following services: police, fire brigade, rescue service, medical service, welfare service, signal service, and transport service.

The police, apart from the maintenance and safeguarding of communications, is in particular concerned with the maintenance and restoration of law and order and has to ensure that the roads are kept clear for access to the disaster area.

The fire brigade, consisting of voluntary and professional units, is responsible for fire-fighting.

The rescue service is charged with the recovery of casualties buried under the debris and with the removal of the dead as well as with the evacuation of sick and old persons and of children from the disaster area; it also assumes the recovery of property and takes relief measures on roads and waterways. The rescue service is carried out by the Federal institution "Technisches Hilfswerk" (see II 1 a).

The medical service has to render first aid to injured and sick people, ensure their removal in co-operation with the fire brigade and rescue service, and bring medical supplies to the scene of damage. The medical service is composed of members of the German Red Cross, the "Arbeiter-Samariter-Bund", the "Malteser-Hilfsdient", and the "Johanniter-Unfallhilfe".

The welfare service has to advise, register, accommodate, and feed the affected population; it has to provide them with clothes and meet any other welfare requirements, and in addition it has to establish the identity of the shelterless, injured and dead in co-operation with the police, the rescue and medical service as well as the "Einwohnermeldeamt" (public registration office). Apart from the voluntary organisations providing the medical service, this work is also carried out by the "Hilfswerk der evangelischen Kirche und Innere Mission", the "Caritas-Verband", the "Deutsche Paritaetische Wohlfahrtsverband" and the "Arbeiterwohlfahrt".

The signal service which has to ensure telecommunication between the Control Centre and the operational elements of disaster relief service is, apart from the police, the responsibility of the "Technische Hilfswerk", the German Red Cross, the "Arbeiter-Samariter-Bund", the "Johanniter-Unfall-hilfe", and in particular the "Malteser-Hilfsdienst".

The transport service is designed to prepare and hold available the means of transport needed in case of a disaster.

This is primarily a function of municipal transport pools, the motor-vehicle pools of Kreis and Regierungsbezirk administrations, and private persons offering their services for such transport operations.

B) The strength of the disaster relief service and the number of its facilities depend on local conditions.

In this connection it may be assumed, that the disaster relief services are provided with all the necessary technical equipment which is generally required for dealing with a calamity. The specialized units have at their disposal the entire equipment available at the municipal or public level, supplemented by the equipment of the voluntary relief organisations.

The relief measures initiated by the Federal Government may, if required, only be co-ordinated by agreement between the various departments concerned. A National Operations Control Centre has so far not been created.

There is also no central control mechanism for co-ordinating the deployment of regional disaster relief elements.

IV. If, in case of a disaster abroad assistance is to be rendered, the Federal authorities - as distinguished from the principles governing inland disaster control - are primarily responsible for co-ordinating the disaster relief capabilities of the Federation, the Laender and the voluntary relief organisations and for ensuring their appropriate deployment in the disaster areas. In this particular case the "Technisches Hilfswerk" and the German Red Cross mobile units, which are financed by the Federation, will primarily be deployed.

V. Precautionary measures for disaster control in a defence emergency are a responsibility of the Federal Government. For this purpose, under the Law Concerning the Extension of Disaster Relief of 9th July, 1968 the existing units and facilities of the peacetime disaster relief service will be reinforced, supplemented, and provided with additional equipment and training so as to enable them to fulfil their tasks also when faced with the special dangers and threats of a defence emergency. The disaster relief service is to be built up on a uniform basis at district level and will comprise, inter alia, units and facilities for fire-fighting, rescue and repair, medical welfare, and signal services. The improvement and reinforcement of disaster relief services naturally will also have a positive effect on the control of peacetime calamities. The Luftschutzhilfsdienst (Civil Defence Service) will, as a first contribution of the Federation, be integrated into the disaster relief service (see II 2).

CCMS No. 2

GERMAN RELIEF OPERATIONS IN DISASTERS ABROAD, 1969/70

Presentation by Germany

1. Sequence of disasters

Between September 1969 and July 1970, the Federal Government rendered effective assistance in five disasters abroad. They were all natural disasters of an unimaginable magnitude.

The first was the flood disaster in Tunisia in September/October 1969 which was followed at the end of October by the earthquake in Yugoslavia. The earthquake in Turkey in March/April 1970 was followed by a flood disaster in Romania at the beginning of May 1970, and before the relief operations for Romania had been concluded, Peru was struck by an earthquake on 31st May, 1970.

2. Causes and consequences

The damage caused by earthquakes and flood disasters showed similar criteria in all cases: concentrated destruction of towns and villages, isolation from the outside world, complete or partial destruction of supply networks, lack of communications, uninhabitable houses, many deaths and casualties. The building methods used in the countries concerned, which disregard the threat of disasters, had helped to increase the extent of damage. A fatalistic mentality (in non-European countries) and the effect of shock made people hardly able to help themselves. They were taxed beyond their material and physical resources. Even a highly civilised country in a similar situation would have had to draw on outside assistance, which is most effective when given quickly and in different forms depending on the type of damage.

3. Nature of assistance

The Federal Government provided goods and services in all cases. The goods comprised drugs and medicines, food, clothing, furniture and equipment, building materials, etc. The services were provided by relief teams with special technical equipment. Principal activities were:

- Preparation of drinking water (German Red Cross (DRK), Technical Relief Organization (THW))
- Erection of emergency shelters (DRK, THW, German Volunteer Service (DED))
- Bridge construction (THW)

- Setting up of field hospital (THW)
- Running field hospital (Maltese Order Relief Service (MHD))
- Installation and operation of radio equipment (DED, THW)
- Recovery of dead (THW)
- Removal of débris (THW)
- Mass feeding (MHD, THW)
- Distribution of auxiliary goods (MHD, THW)
- Medical care for helpers (THW, MHD, St. John's Accident Service (JUH)).

Goods and services were provided either as emergency measures (humanitarian phase) or in aid of reconstruction (reconstruction phase), as indicated by their sequence. The Federal Government's assistance always covered both phases, though naturally with greater emphasis on emergency measures.

4. Commencement and duration of relief operations

Measures for the humanitarian phase were started not long after the beginning of disasters, as soon as the offer of assistance or the request for help had been accepted.

On the instructions of the Federal Ministry of the Interior, where an emergency committee co-ordinated measures by Federal departments and relief organizations, the Federal Civil Defence Agency formed an operations committee which was in readiness day and night.

The emergency measures of the humanitarian phase were started two to ten days after the disaster and lasted for two to five weeks. The provision of personnel and auxiliary goods was the task of the operations committee. Auxiliary goods were taken out of civil defence stores or purchased through the Federal procurement authority. All operations of the humanitarian phase were made particularly urgent. There was never much time for planning, preparation and organization.

The reconstruction phase left more scope for preparations. It started in most cases 5 to 6 weeks after the start of the disaster. Typical projects of that phase are the construction of prefabricated houses, stationary hospitals and bridges, including the supply of materials and assignment of expert personnel for advisory services.

5. Areas in which relief operations took place

Climate and geography in relief areas are sometimes quite different from those in Europe. In South America (Peru), at 8 - 12° Southern Latitude, relief operations are a greater strain on personnel and equipment than they would be in Europe. New criteria will have to be worked out regarding the technical equipment, relief workers' outfit and the suitability of helpers.

In some cases the teams provided by the Technical Relief Organization and other organizations concentrated on certain areas or places. Concentrated operations are easier to direct than measures in decentralized areas. Scattered relief areas, such as in Tunisia and Peru, require a broader base for supplies, operational and transport means, and more than one person to direct operations.

THE PREDICTION OF SEA TIDES AT VENICE

by S. Palmieri and G. Finizio (Italy)

1 - INTRODUCTION

The present paper illustrates the results of a study carried out in the framework of the "Comitato per lo Studio dei Provvedimenti a Difesa della Città di Venezia", as a collaboration between the "Servizio Meteorologico dell'A.M." and the "Istituto di Fisica dell'Atmosfera" of C.N.R., and shall be considered a development of a previous study published by "Rivista di Meteorologia Aeronautica" (25).

The study is proceeding along two main lines, the first one facing the problem of the prediction of high water at Venice from an empirical point of view with the support of the knowledge so far acquired and of some working hypotheses; the second one based on physical-mathematical models of the Adriatic sea. The numerical models, which include a proper formulation of the sea-air interaction, starting from the knowledge of the initial and boundary conditions, allow computation of the space and time distribution both of the sea level and the sea currents.

In this paper the results obtained by following the first line of approach are reported.

2 - SEA LEVEL OBSERVATIONS AND FREQUENCY DISTRIBUTION OF "HIGH WATERS" AT VENICE.

A list of occurrences of sea levels exceeding 110 cm at Venice-Punta della Salute is available (the level is measured assuming as a "zero" the mean sea level of the year 1897). Variations between maxima and corresponding previous minima are also included (1). The measures are taken in a reference fixed on the ground: when the sea level exceeds 110 cm the first floods affect the lowest sections on the town. The term "high water" will be used throughout this report to indicate a level equal to or greater than 110 cm.

When the present study started the sequence of hourly measures of the sea level was also available for three consecutive years (1966, 1967, 1968).

It is assumed that the factors normally affecting the sea level are:

a) wind and atmospheric pressure;

b) astronomical tides;

c) subsidence of the ground;

d) causes of general nature like the melting of the polar ice cap.

Factors c) and d) have been carefully considered by S. POLLI (18) and F. MOSETTI (2) (3).

The frequency distribution of all cases of high waters (sea level equal to or greater than 110 cm above the mean sea level of 1897) is shown in fig. 1 (continuous line), together with the frequency of cases of sea level equal or greater than 110 cm above the mean annual sea level (dashed line).

It is worth noticing that the continuous line histogram represents the frequency of the phenomenon when factors a) b) c) d) are included, while the dashed histogram shows the frequency

[illegible]

Although based on a limited number of cases, the two distributions have the same characteristics: a maximum in November and a similar skewness. Factors c) and d) do not seem to alter the main features of the frequency curve.

Considering that the astronomical tide is a periodic function of time whose first component has a period of about one month, it is reasonable to state that the astronomical tide does not significantly contribute to the frequency distribution.

There is good evidence that the main characteristics of the frequency distribution are brought about by atmospheric factors. The largest number of high waters in the months of November and December is certainly related to the maximum number of cyclogeneses occurring in these months over northern Italy (5).

Furthermore the highest frequency of secondary depressions in the lee of the Alps is recorded in November, the main deep low pressure area being located over Britain (4).

In conclusion, the frequency distribution of high waters at Venice is related to the frequency of cyclogenesis over northern Italy and Adriatic sea. The skewness of the distribution may find a reasonable interpretation in the fact that cyclogenesis in the said area is more frequent on January and February than in September and October (5).

3 - RELATIONSHIP BETWEEN HIGH WATERS AND METEOROLOGICAL SITUATIONS

It was thought useful first of all to identify the main characters of meteorological situations associated to the appearance of high water at Venice. To this purpose, reference was made to a method of classification of euro-atlantic weather types (6) including a daily catalogue since 1899. The 57 high waters were considered which were recorded since 1900 and reported in (I). Sea level maxima which occurred on the same day or on successive days were reguarded as one case. The results of the investigation appear in the following table:

Number of cases	Frequency %	Description of situation
24	52.1	The circulation is controlled by a depression over Western Europe or over Mediterranean. In 18 of these cases the main low pressure is centered over Britain (Example of Fig. 2).
19	41.3	Zonal circulation over Atlantic. High pressure over Eastern Europe interrupts the zonal flow causing southerly winds over Adriatic and Balcans. (Example of Fig. 3).
3	6.6	Zonal circulation: Disturbances moving from SW to NE over Atlantic.

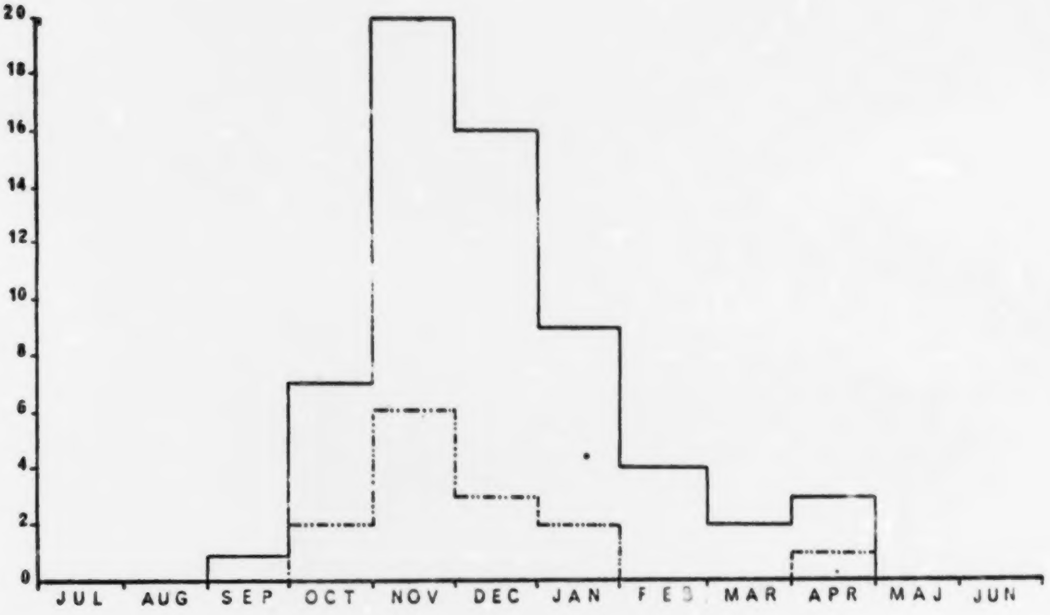


Fig. 1 - Frequency distribution :

a) - (——) - Cases in which the sea level was greater than or equal to 110 cm, assuming as zero the mean sea level during the year 1897;

b) - (-··-) - Cases in which the sea level was greater than or equal to 110 cm, assuming as zero the mean annual sea level.

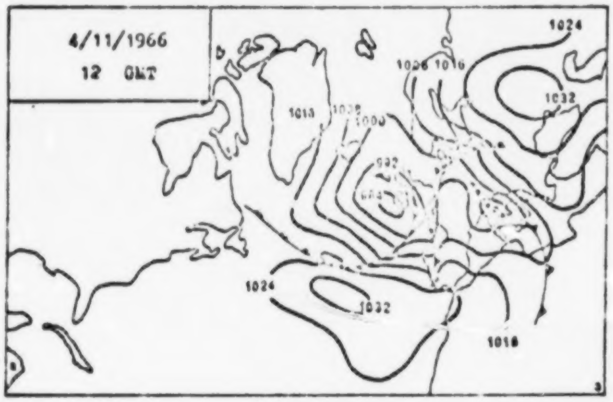

4/11/1966
12 GMT
1024
1032
1016
1000
1024
1032
1016

Fig. 3 - Surface meteorological chart of a typical case of high water characterized by a deep depression over Britain and also by an intense blocking high pressure area over Russia and Balkans.

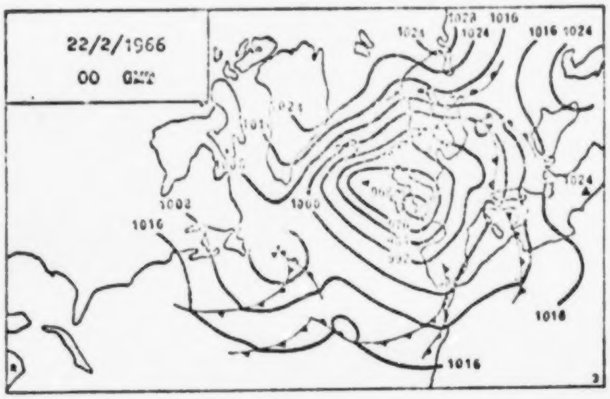

22/2/1966
00 GMT
1028
1016
1024
1024
1016
1024
1008
1016
1000
1024
1016
1016

Fig. 2 - Surface meteorological chart corresponding to a tipical case of high water and characterized by a deep depression over Britain.

This preliminary analysis, which will later on be integrated by a detailed study in space and time of single cases, leads to conclusions in agreement with previous researches (7): the increase of sea level occurs with surface pressure patterns such as to bring about southerly winds in a fairly large area, roughly extending from 10 to 20 degrees longitude east, between the latitudes of 35 and 45 degrees north. This type of pressure pattern seems to offer a first criterion to evaluate the probability of increasing sea levels. In particular synoptic weather charts indicated a predominant feature to be a deep depression over Britain. A second characteristics is a blocking high pressure area centered over eastern Europe.

4 - DETAILED ANALYSIS OF FACTORS RESPONSIBLE FOR THE METEOROLOGICAL COMPONENT OF THE TIDE

The hourly sea level data of the year 1966, including an extreme sea level height, were carefully considered in a first stage. For each day a form was prepared in which all the meteorological elements were entered, as reported by a number of Italian and Jugoslav weather stations. The analysis of these reports, together with the study of three-hourly meteorological charts, indicated three main factors affecting the increase of the sea level at Venice.

- Wind pattern over the Adriatic sea
- External source
- Local situation

In addition one has to consider the direct effect of the atmospheric pressure.

4.I - Wind pattern over the Adriatic sea.

As mentioned in sections 2 and 3, the most favourable condition for the increase of the sea level at Venice is the existence of a depression over northern Italy and the consequent appearence of strong southerly air currents in the Adriatic basin. Depending on the location and intensity of the depression, the actual air flow may blow from any direction between southeast and southwest. By all means the greatest contribution to the surge is provided by the existence of south-east winds over the whole basin as was the case of November 4th 1966. The existence of south-east winds does not necessarily require a strong pressure gradient across the basin (south-west to north-east). In fact the canalization effect of the dalmatian highground only permits, at low levels, currents which are parallel to the coast, that is to say parallel to the main axis of the Adriatic, preventing the Coriolis force from balancing the pressure gradient. The resulting cross-isobar component from south-east is therefore controlled by the pressure difference between the southern and northern end of the basin. For this reason, also situations with isobar patterns such as to produce a general southwest geostrophic flow, are in fact favourable to the occurrence of surges; moreover situations of this type, due to their relatively high frequency represent the most common pressure distribution associated to the phenomenon.

The maps shown in fig. 4, 5 represent a typical case. In particular a strong air flow along the coast of Jugoslavia is present, while light winds of variable direction appear on the Italian coast of the Adriatic.

4.2 - External source

The analysis of several meteorological situations associated to surges in the northern Adriatic indicated that a typical pressure pattern over the central Mediterranean and Ionian sea may well have been the only operating factor: a depression centered south of the Ionian sea drifting eastward (fig. 6). A situation of this type gives rise to southerly surface winds over a large area. It may be inferred that the said wind distribution, under the constraint of orography (Ionian coasts of Sicily, Calabria and Greece) interacts with the sea in a way to favour a surge in the Adriatic sea.

4.3 - Local situation

The local situation over the northern Adriatic may also be a key factor whenever a depression centered somewhat south of the region causes strong surface easterly winds in the uppermost portion of the sea. An example is shown in fig. 7.

The interesting remarks reported by S. VERONESE (9) are in quite good agreement with the concepts discussed in subsections 4.I and 4.3.

5 - ESTIMATE OF ATMOSPHERIC FACTORS RELATED TO THE INCREASING SEA LEVEL AT VENICE BY MEANS OF METEOROLOGICAL DATA.

5.I - Objective characterization of meteorological situations by means of proper indices.

With the intent to provide a quantitative estimate of the factors related to surges it has been assumed that:

5.I.I. - The wind-sea interaction causes an effect on the sea level proportional to the square of the wind speed; this is a consequence of the generally accepted assumption that the surface stress of the wind is proportional to the square of the wind speed (I0)(II)(I2).

5.I.2. - The various factors which influence the sea level, including the astronomical tide and the direct effect of the atmospheric pressure, operate through physical processes which may be considered indepedent (I2). In reference to the wind pattern over the Adriatic, as

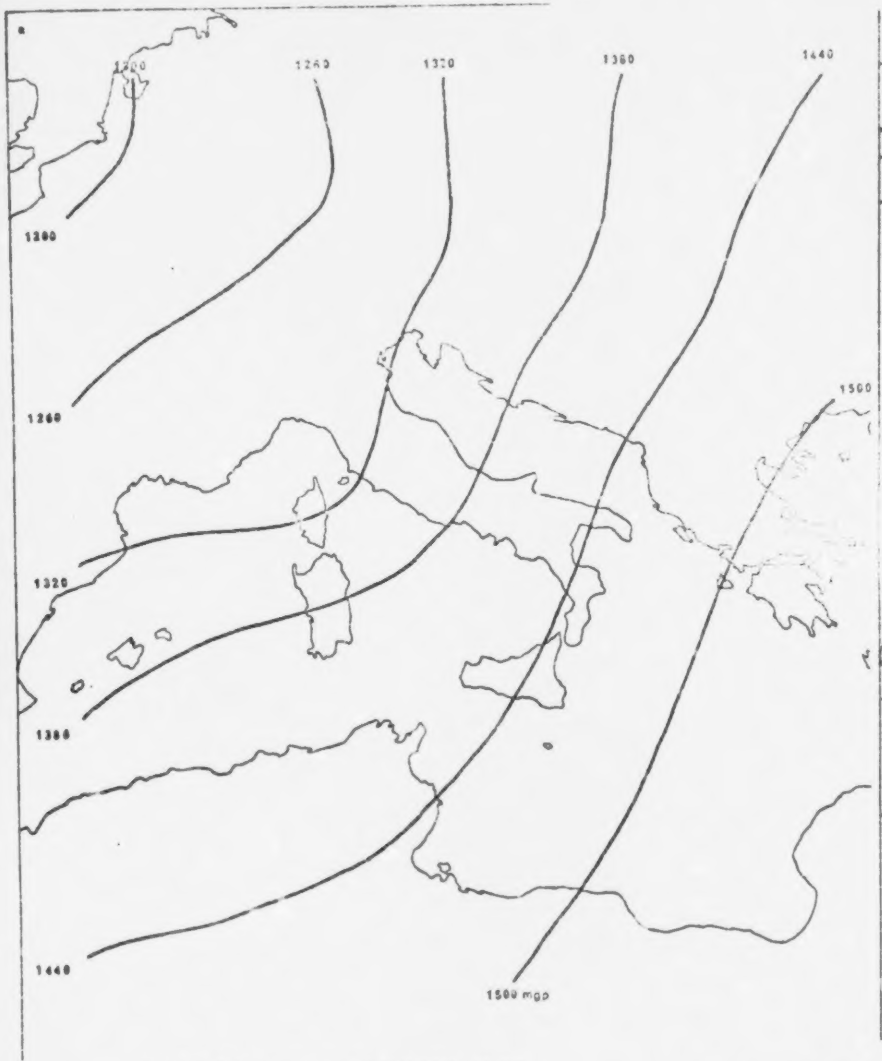
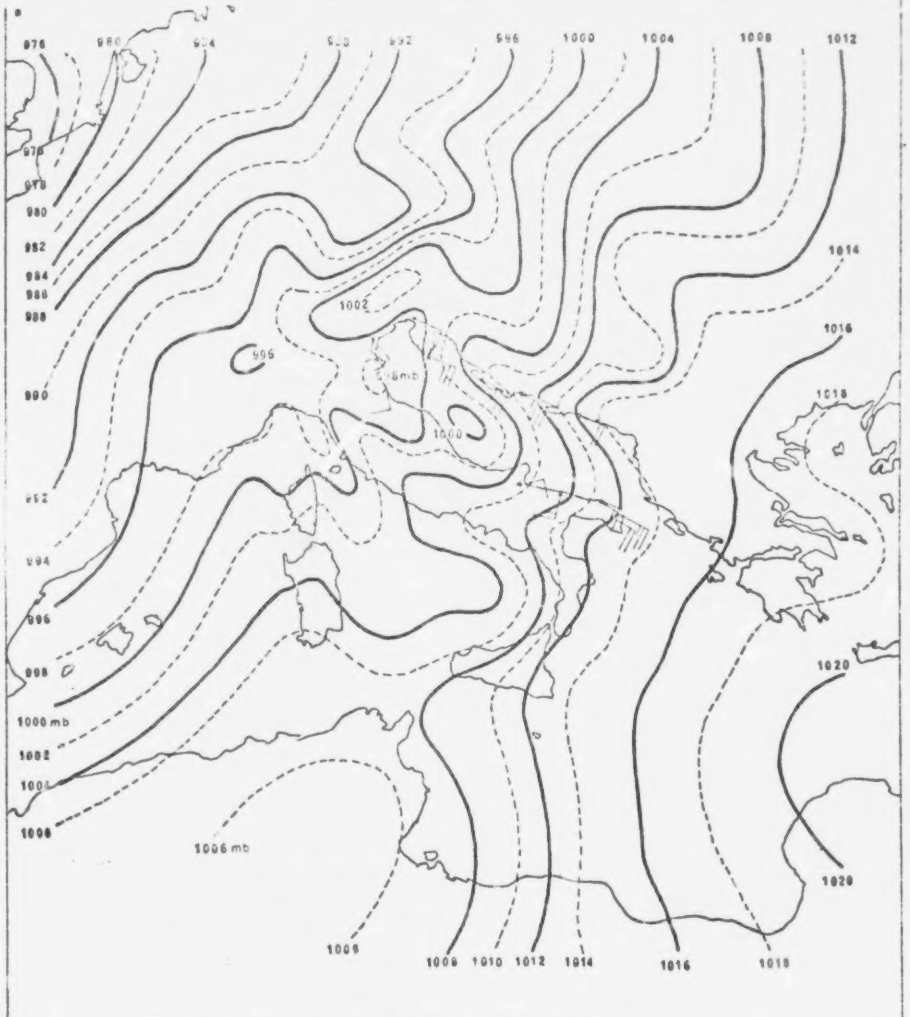

1200
1240
1320
1360
1440
1500
1280
1260
1320
1380
1440
1500 mgp

Fig. 5 = 850 mb contours of 22/2/1966, 00 GMT.


976
980
984
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992
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1004
1008
1012
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996
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1000 mb
1002
1004
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1002
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998mb
1000
1006 mb
1008
1008
1010
1012
1014
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1018
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1016
1018
1020
1020

Fig. 4 = Surface pressure field of 22/2/1966, 00 GMT

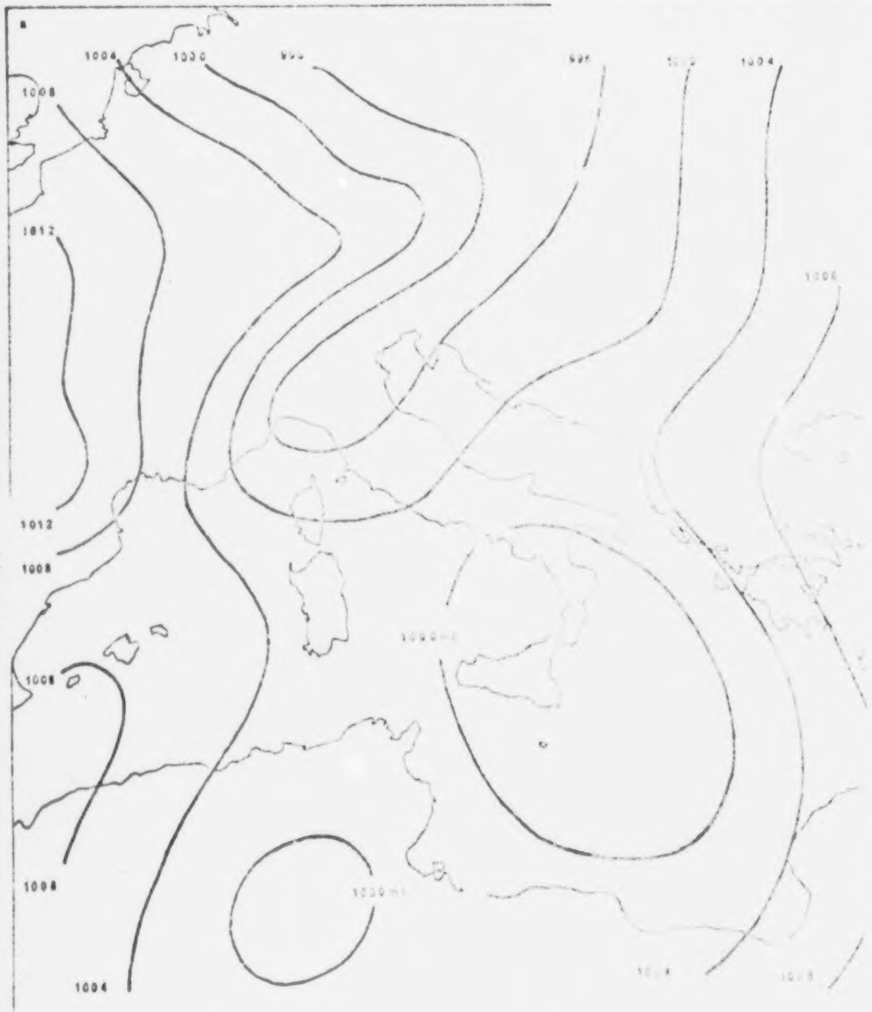
1004
1008
1012
1012
1008
1008
1008
1004
1000 mb
1000 mb
996
1004
1008
1004
1008

Fig. 6 = Surface pressure field of 21/4/1967, [illegible]

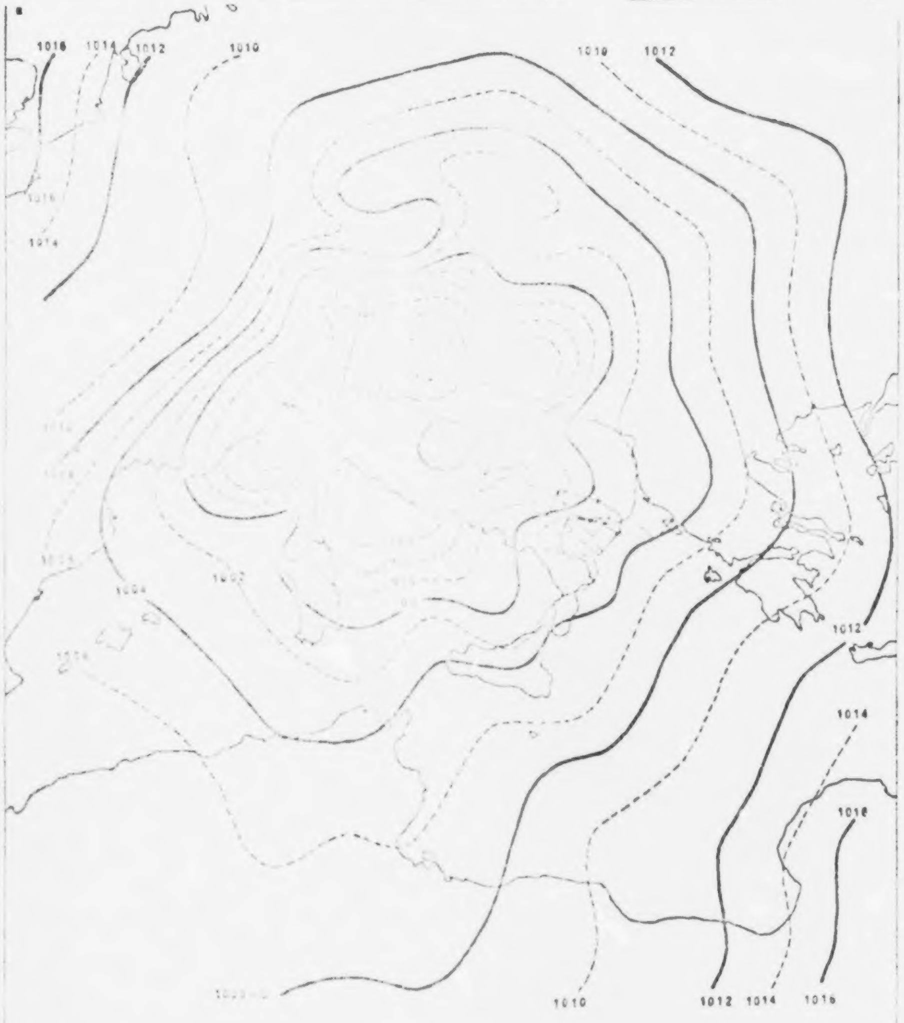
1016
1014
1012
1010
1016
1014
1010
1012
1002
1004
1006
1012
1014
1016
1000 mb
1010
1012
1014
1016

Fig. 7 = Surface pressure field [illegible], 21 GMT.

discussed in subsection 4.I, as far as the cross-isobar flow is concerned, being the pressure gradient the main effective force, one may assume that the said component is proportional to the pressure difference between Santa Maria di Leuca and Venice:

(5.I.3) $$A_I\,(p_I - p_2) \qquad p_I > p_2$$

where A_I is a coefficient depending on the wind-pressure relationship, p_I and p_2 are respectively the pressures at Santa Maria di Leuca and Venice.

In addition to the component of wind expressed by (5.I.3) one has to consider the actual southeasterly component of wind blowing along the isobars which is accounted for by the pressure difference perpendicular to the main axis of the sea. If p_3 is the atmospheric pressure at Spalato and p_4 the pressure at Pescara, such component may be given by

(5.I.4) $$A_2\,(p_3 - p_4) \qquad p_3 > p_4$$

Note that the angle formed by the axis of the basin and the line joining the two said stations exceeds a right angle by about I0-I5 degrees; this provides an easy way to take into account the deviation of wind with respect to the isobars, due to the surface friction (I2).

Assuming the two components (5.I.3) and (5.I.4) to be independent, the total effect on the sea level, according to assumption 5.I.I., is given by

(5.I.5) $$\begin{aligned}\Delta h_I &= c \cdot \Big[A_I\,(p_I-p_2) + A_2(p_3-p_4)\Big]^2 \\ &= \Big[a_I\,(p_I-p_2) + a_2(p_3-p_4)\Big]^2\end{aligned}$$

Referring to the external source (subsection 4.2) since the action of the wind on the sea level decreases with depth (I2), the Ionian sea being relatively deep, the effect will be appreciable only if the wind is active over a considerable part of the sea; for this reason this factor should play an important role when a favourable pressure pattern sets in, not only near the Otranto channel, but over the whole central Mediterranean.

According to the line previously followed, the effect on the sea level may be given by

(5.I.6) $$\Delta h_2 = a_3\,(p_7 - p_8)^2 \qquad p_7 > p_8$$

where $p_7 - p_8$ is the pressure difference between the two points 35N, 22.5E and 35N,I7.5E, interpolated from the available pressure fields.

As far as the local situation is concerned (subsection 4.3), this is very important element whenever the situation is characterized by strong easterly winds over the northern Adriatic. In this case a suitable index related to the wind is the pressure difference between Trieste and Pola. The corresponding increase of the sea level may take the form

$$\Delta h_3 = a_4(p_5 - p_6)^2 \qquad p_5 > p_6 \tag{5.I.7}$$

where p_5 and p_6 are the pressure respectively at Trieste and Pola.

Finally one has to introduce the direct effect of the atmospheric pressure. Since the density of the sea water is about I.03 g/cm^3, a pressure difference of I mb corresponds to a sea level difference of about I cm (I2), provided the hydrostatic equilibrium has been reached. On the other hand, due to friction a stationary state is probably never attained and the actual effect is very likely to be of smaller magnitude. This is true in the case of a slowly variable pressure difference between northern and southern Adriatic. On the contrary if a fast moving perturbation of the pressure field were passing through the area, resonance might occur between the aforementioned perturbation and the consequent effect on the sea. In these circumstances effects much larger than those predictable by the hydrostatic law might be experienced. As a matter of fact the analysis of many meteorological situations associated with surges seems to indicate that the phenomenon is not related to fast moving pressure disturbances. In conclusion the static effect of the atmospheric pressure may be expressed by

$$\Delta h_4 = a_5(p_I - p_2) \qquad p_I > p_2 \tag{5.I.8}$$

If d_I is the distance Venice-Santa Maria di Leuca and d_2 the distance between Venice and the southern Adriatic where, on account of the great depth, the variations of the sea level are so small to be for our purposes negligible, one has

$$a_5 = \frac{d_2}{d_I} = \frac{500}{800} \simeq 0.65 \qquad (d_i \text{ in km}) \tag{5.I.9}$$

The space distribution of the points where the atmospheric pressure is needed to carry out the calculation of Δh, is shown in fig. 8.

5.2 - Sea level increase. Determination of the empirical coefficients.

According to assumption 5.I.2. the contribution of each factor may be added up to get the resultant effect on the sea level

$$\Delta h = \left[a_I(p_I - p_2) + a_2(p_3 - p_4)\right]^2 + a_3(p_7 - p_8)^2 + a_4(p_5 - p_6)^2 + a_5(p_I - p_2). \tag{5.2.I.}$$

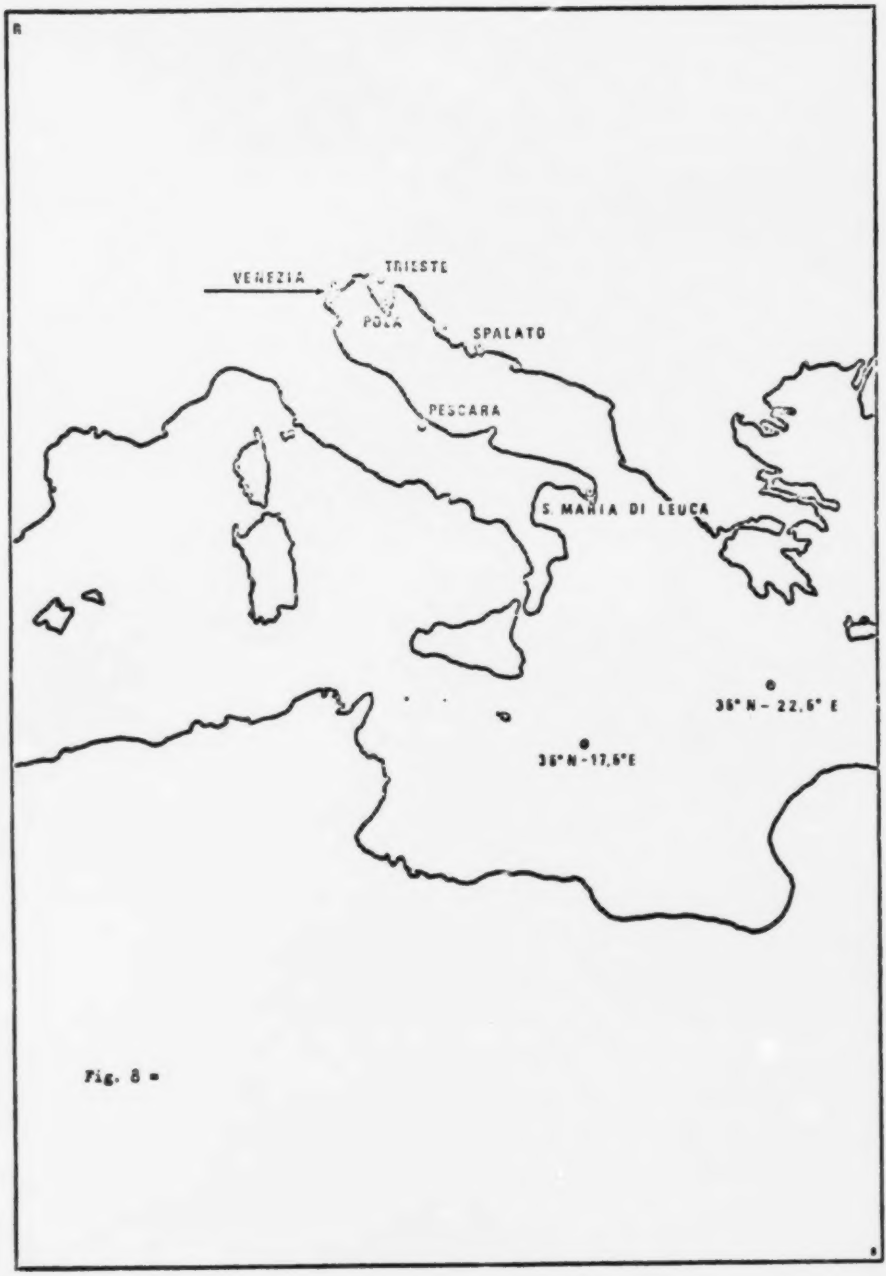
VENEZIA
TRIESTE
POLA
SPALATO
PESCARA
S. MARIA DI LEUCA
36° N - 22,5° E
36° N - 17,5° E

Fig. 8 -

The next problem is to determine on the base of the available data the four coefficients (a_1, a_2, a_3, a_4) appearing in eq. (5.2.1.). With this intent a number of fully documented cases have been collected.

The zero level has been assumed to be the mean sea level of 1897 plus 22 cm to account for the ground subsidence during the past 70 years (3).

In accordance with (12) the tides were represented as a superposition of a set of partial simple harmonic tides for which the characteristic constants are known. The height of the astronomical tide can thus be calculated for any moment and subtracted from the actual sea level to get the meteorological component. Cases have been selected in which the latter was equal to or greater than 35 cm.

For each case three-hourly very detailed weather charts of the Adriatic sea have been gathered, together with six-hourly synoptic charts of the Mediterranean area. The considered cases belong to the years 1966,67,68: for this period the "Osservatorio Geofisico Sperimentale" of Trieste has provided the hourly sea level observations on punched cards and the results of the application of various filtering operators to these time-series.

A preliminary investigation has been carried out on the time series of the sea level from which the astronomical tide component was previously filtered out and the time series of the pressure difference along the major axis of the Adriatic which, in most cases, largely contributes to the development of south-east currents, as discussed in section 4.1. The curve of fig. 9, namely the cross covariance of the said time series as a function of the time lag (the series of meteorological data leads that of the sea level) clearly indicates a maximum at a time lag of 3 hours.

This might also be expected on the base of theoretical considerations on the propagation of gravity waves in a channel (**).

It was therefore decided to proceed in the determination of the a_i 's using pressure differences preceeding by 3 hours the corresponding sea level maximum. Linearization of the first term appearing on the right side of eq. (5.2.1.) by putting $2 \cdot a_1 \cdot a_2 \simeq a_1^2 + a_2^2$ allowed reducing the determination of the a_i 's to a linear least squares problem for which the solution is offered by standardized well known techniques (24).

Out of the total number of available cases 17 have been used to obtain a first determination of the a_i while the remaining 7 have been used to evaluate the efficiency of the model. Thereafter the coefficients have been computed again (a_i^*) on the base of all cases, to get some indication on their stability.

The root mean square errors (RMSE and RMSE *) have been also computed.

(**) The propagation speed is given by $v = \sqrt{gH}$ where g is the acceleration of gravity and H the depth of the channel. When the factor is operating over the Central Adriatic with an average depth of 100 m and a distance of 400 km, about 3 hours are necessary for a wave to move from the lower to the upper end of the Adriatic.

The results, if Δh is given in cm and p in [illegible], are shown in the following table:

17 cases 1966 - 1967 a_i	24 cases 1966-1967-1968 a_i^*	percentage variation of coefficients $\frac{a_i^* - a_i}{a_i}$
$a_I = 0.32$	$a_I^* = 0.33$	+ 3%
$a_2 = 0.52$	$a_2^* = 0.48$	- 8%
$a_3 = 0.56$	$a_3^* = 0.53$	- 5%
$a_4 = 3.73$	$a_4^* = 4.20$	+13%
RMSE = 6.5 cm	RMSE* = 10 cm	

Referring to the preceeding table, a_4 appears to be the less stable coefficient, while a_I did not change appreciably from the first to the second determination. The coefficient a_4 represents the local effect: the situations in which it played an important role were relatively few and this partly explains the grater variability. In addition, due to the relatively small area involved it might well be possible that the interactions between sea currents and coastal boundaries require a more sophisticated scheme to take this effect into account. Viceversa a_I, expressing the effect of the ageostrophic component, is particularly stable because this factor is present in the majority of cases.

The high stability of a_I and its relatively large value as compared to a_2 (the pressure difference $p_I - p_2$ is generally large with respect to $p_3 - p_4$ due to the great distance between S. Maria di Leuca and Venice) support the remarks given in 4.I. about the importance of the pressure gradient between the southern and northern end of the Adriatic, as a factor contributing to the development of the south-east flow.

It may be noted at last that the values of the coefficients found by means of the indicated method do not differ appreciably from those determined by a technique based in minimization of the mean absolute error (25).

5.3 - Application of the proposed method.

For the purpose of computing the predicted value of Δh 3 hours in advance one may use either (5.2.I.) or its linerized form (***).

(***) The determined values of a_1 and a_2 allow an estimate of the error inherent in using the (5.2.1.) instead of its linearized form which was actually utilized for the evaluation of the coefficients.

It must be stressed that the proposed model is only capable of dealing with the first increase of the sea level directly caused by meteorological factors. Neither the subsequent decrease of the sea level nor the consequent oscillation which may occasionally set in, are predictable by means of this method.

The overall efficiency of the model has been evaluated taking into consideration the whole sea level rise stage of each case.

As an efficiency index the ratio of the variance accounted for to the initial variance ("no model") has been computed. The latter is given by

(5.3.I.) $$F_o^2 = \sum (y - \bar{y})^2$$

while the residual variance may be expressed

(5.3.2.) $$F^2 = \sum (y - \Delta h)^2$$

where y is the actual meteorological component, of the tide, $\bar{y}$ is the mean of y and Δh is the predicted component. The efficiency index is then

(5.3.3.) $$R^2 = \frac{F_o^2 - F^2}{F_o^2}$$

(*)

Putting

$$p_I - p_2 = X_I, \quad p_3 - p_4 = X_2 \quad \text{and} \quad a_2 = a_I + k$$

the first term of (5.2.I.) is, in the non linear form:

$$a_I^2 X_I^2 + (a_I+k)^2 X_2^2 + 2a_I(a_I+k) X_I X_2$$

and in the linearized form $(2a_Ia_2 \simeq a_I^2 + a_2^2)$

$$a_I^2 X_I^2 + (a_I+k)^2 X_2^2 + a_I^2 X_I X_2 + (a_I+k)^2 X_I X_2$$

The error involved in using the initial form of (5.2.I.) is then $K^2X_IX_2$ if k is a_2-a_I.

The relative error with respect to the whole first term is

$$\mathcal{E}_r = \frac{K^2 X_1 X_2}{a_1^2 X_1^2 + (a_1+K)^2 X_2^2 + (2a_1^2+2a_1K+K^2)X_1X_2}$$

The values of R^2 are reported in the following table

DAYS	R^2
2/3-II-1968	0,93
I7-I2-I968	0,90
7- I-I968	0,90
24-2-1968	0,73
22-9-I968	0,08
I6-II-I968	0,95
8/9-I2-I968	0,85

The overall value of R^2 , as computed on the bsae of all cases, is

$$R^2 = 0{,}89$$

As a second step it has been considered necessary to asses how good the assumed time-lag of three hours was. For this purpose the time intervals between predicted and observed maxima in the seven cases of 1968 have been determined. The average time lag turned out to be 3½ with a standard deviation of 2 h, in agreement with the assumed value. The relatively large fluctuations around the mean can be accounted for by differences in the situations: as was shown, in some cases, when the main cause responsible for the sea level increase is operatinng over the northern Adriatic, very close to Venice, very small time lags should be expected. On the other hand, when a favourable mechanism is active over the Ionian sea, a maximum cause-effect delay is very likely to occur.

Assuming $X_I = cX_2$ with $a_I \simeq 0{,}32$ e $K \cong 0{,}2$, one has

$$\varepsilon_r = \frac{4c}{10c^2 + 37c + 27}$$

ε_r as a function of c is shown in fig. IO. The maximum value is reached when $c = I.64$

$$\varepsilon_r = 5{,}75\%$$

On account of the small value of $\varepsilon_{r_{max}}$ and of the fact that it refers only to first term, it is clear that, for computing, either of the two forms of (5.2.I.) may be used.

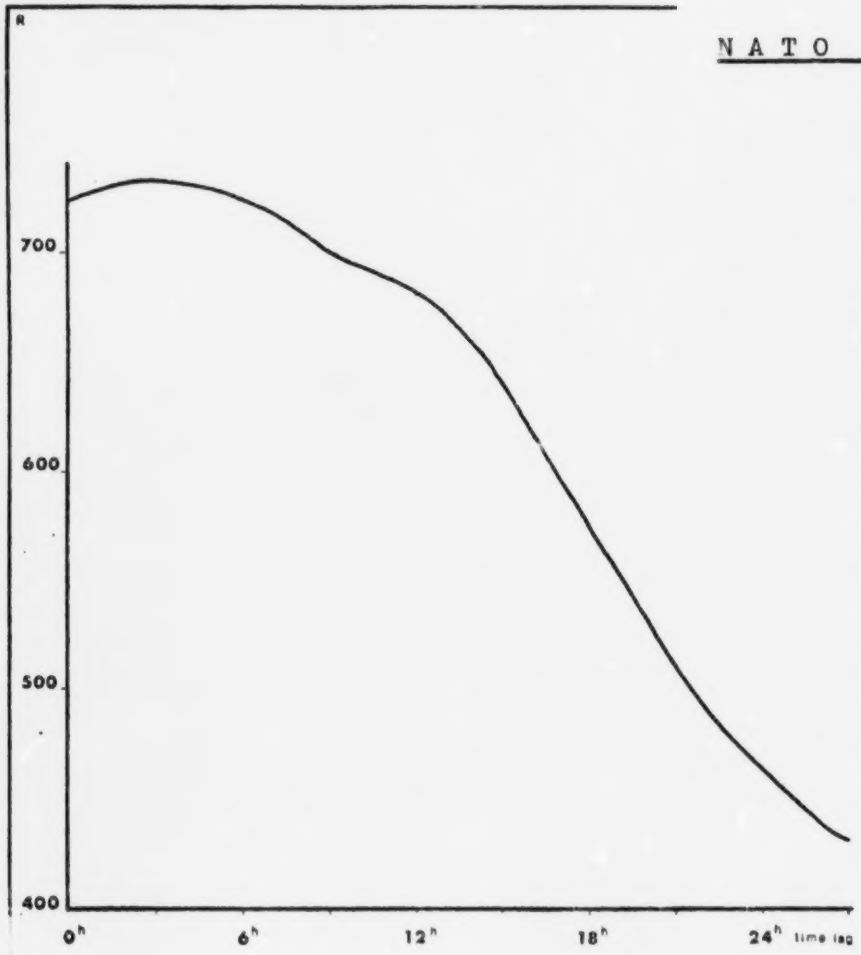

Fig. 9 = Cross-covariance as a function of the time lag.

The two series concerned are the meteorological component of the sea level at Venice and the pressure difference between S.Maria di Leuca and Venice.

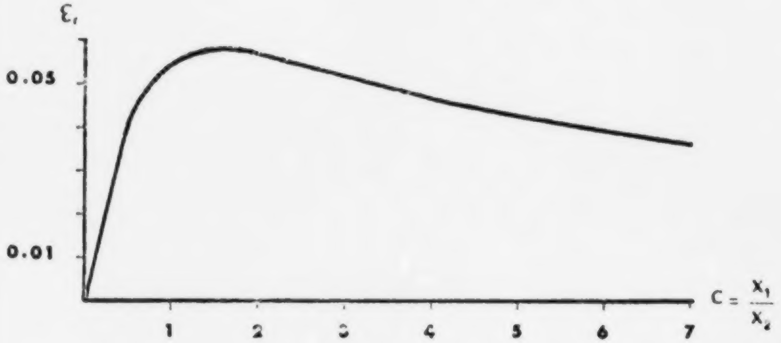

Fig. 10 = ε_r versus C

The actual and predicted meteorological component of the tide are shown in fig. II, I2, I3, I4, I5, I6, I7. It is interesting to note that there are cases in which the meteorological conditions favourable to the phenomenon persisting for a certain time, the computed effect is also nearly stationary; viceversa when the causing factors have a short life cycle the same is true for the actual component of the tide. This is very encouraging and indicates that the selection of predictors together with the basic assumptions where fortunate.

Fig. I8, I9, 20, 2I illustrate the surges of I966 and I967 and the corresponding three-hourly predictions. In the exceptional case of november I966 (fig. I9) the term representing the wind pattern over the Adriatic (first term on the right side of 5.2.I.) was very large due to the coexistence of a deep depression over northern Italy and a blocking high pressure over eastern Russia and the Balkan peninsula. Also, the external source term and the static effect of pressure, gave an appreciable contribution in this case.

Two cases are also presented (fig. 22, 23) in which in spite of the large meteorological component no high water occurred. In fact, as fig. 24, 25 show, the maxima of the meteorological components appeared in concomitance with minima of the astronomical tides. In other cases the reverse is true and high water is observed even if the meteorologocal component is not too large (fig. 26, 27).

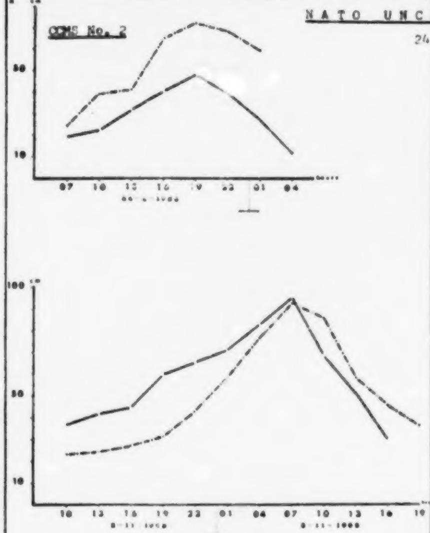

Fig. 11 - 12 = Actual meteorological component (——), three-hourly prediction of the same quantity (-·-·).

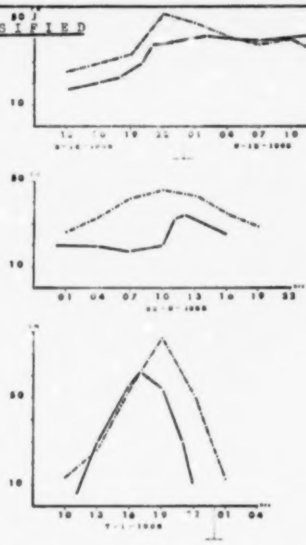

Fig. 13 - 14 - 15 = Actual meteorological component (——), three-hourly prediction of the same quantity (-·-·).

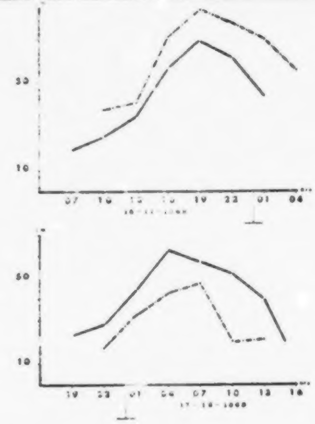

Fig. 16 - 17 = Actual meteorological component (——), three-hourly prediction of the same quantity (-·-·).

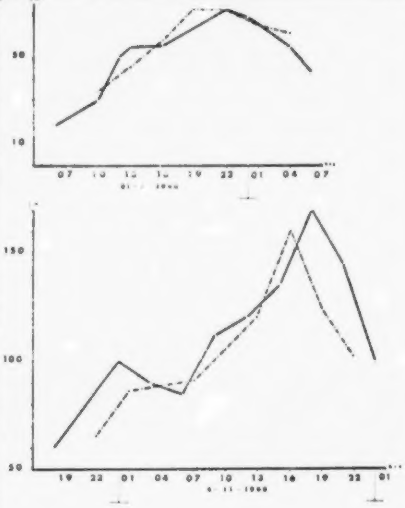

Fig. 18 - 19 = Actual meteorological component (——), three-hourly prediction of the same quantity (-·-·).

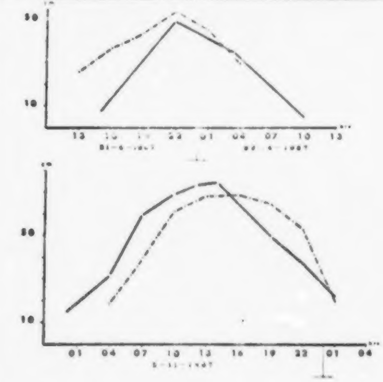

Fig. 20 - 21 = Actual meteorological component (——), three-hourly prediction of the same quantity (-·-·).

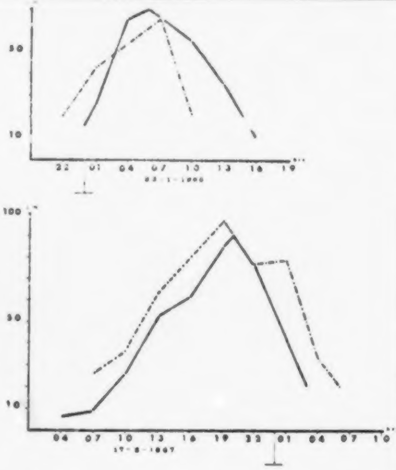

Fig. 22 - 23 = Actual meteorological component (——), three-hourly prediction of the same quantity (-·-·).

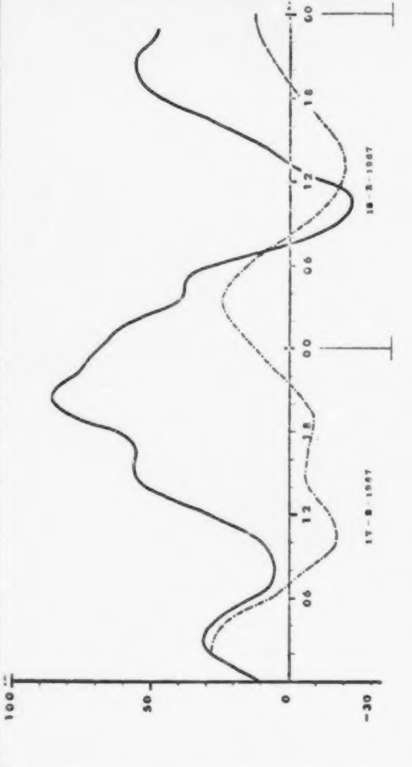

Fig. 24 = Actual sea level (——); astronomical tide (-.-).

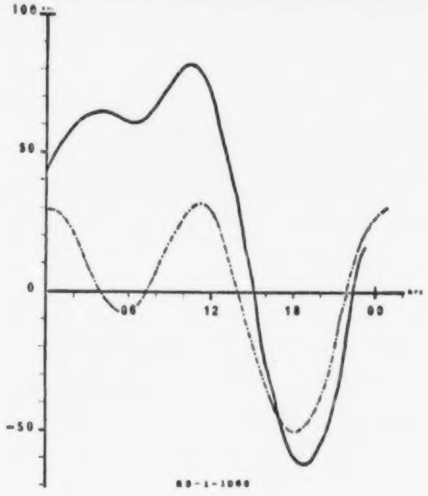

Fig. 25 = Actual sea level (——); astronomical tide (-.-).

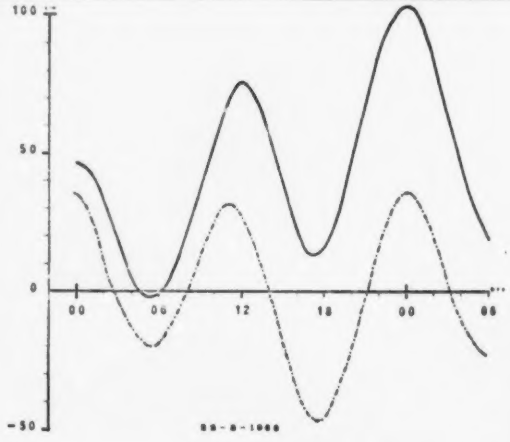

Fig. 26 = Actual sea level (——); astronomical tide (-.-).

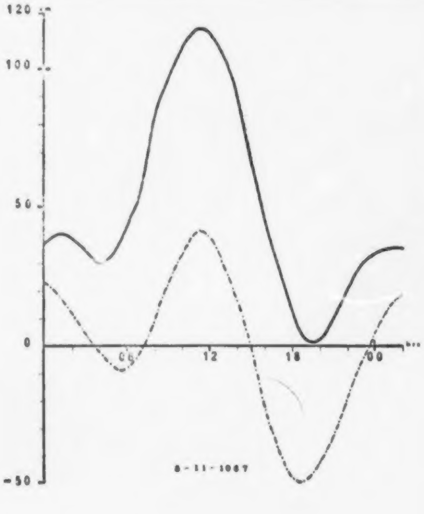

Fig. 27 = Actual sea level (——); astronomical tide (-.-).

6 - PREDICTION OF HIGH WATERS

Although based on a limited sample, the results given in the previous section are very encouraging and an attempt is made here to develop them from an operational point of view.

The final intent of the study is obviously that of providing an objective system for issuing warnings to the people and to the authorities of Venice. The problem may be split in two parts:

a) the quantitative forecast of the likelyhood of the phenomenon as may be inferred by the large scale features of the meteorological fields (surface pressure in particular). As pointed out by F. CERASUOLO (7) such a general type of forecast can be produced 24 hours in advance on the base of the standard products of the national Meteorological Service.

b) The quantitative forecast of the sea level, as is permitted by the proposed method for a very limited time range (3 hours).

In reference to b) one might look forward a "real time" acquisition system of meteorological coastal data from automatic weather stations. On the other hand before moving along this line it is necessary to find out whether, and to what extent, use can be made of predicted pressure instead of actual pressure in the practical application of eq. (5.2.I.).

In reference to this problem it is useful to see how errors in the pressure differences appearing in (5.2.I.) affect the results of computation.

According to the law of error propagation one has:

$$\frac{\partial(\Delta h)}{\partial(p_1 - p_2)} \simeq 4$$

$$(6.I.I.) \qquad \frac{\partial(\Delta h)}{\partial(p_3 - p_4)} \simeq 7 \qquad \mathrm{cm \cdot mb^{-1}}$$

$$\frac{\partial(\Delta h)}{\partial(p_5 - p_6)} \simeq 6$$

$$\frac{\partial(\Delta h)}{\partial(p_7 - p_8)} \simeq 7$$

Prognostic fields of pressure, distributed by the Meteorological Service for aviation and general use are available for validities extending to 24-48 hours. This fields are affected by a root mean square error in the prediction of local pressure of about 4-5 mb (I5); this is equivalent to a probable error of 3-3.5 mb. That is to say in the 50% of all cases the error is greater than the said value.

It may be added that interest here is focused on pressure differences in space; since prediction errors are generally correlated in space, errors in pressure differences should be somewhat smaller than the sum of errors on local pressures. Nevertheless, considering (6.I.I.), these errors are too large to allow the use of the ordinary predicted pressure values to compute the meteorological component of the sea tide by means of (5.2.I.) 24-48 hours in advance. On the contrary a simple objective forecasting scheme based on the experimentally determined relationship between the local variation of pressure in three hours and the corresponding change of pressure during the subsequent three hours, provides a reasonable way to increase the time range of the prediction without appreciable deterioration of the quality of results. Following this line, a scatter diagram has been prepared on the basis of about a hundred cases expressing the empirical dependence of the said pressure tendencies. The curve of "best fit" was then found by a least squares technique (fig. 28). A relationship of this type may be interpreted, from a mathematical point of view, as a relation between time derivatives approximated by backward and forward finite differences: one might therefore expect a resultant curve very close to the bisectrix of the coordinate axes. The actual curve is different and this can be explained with simple considerations of a physical nature. The curve has been obtained by considering only those cases in which an increase of the sea level was observed, namely situations of cyclonic development over northern Adriatic. The initial stage is generally characterized by $\frac{\partial p}{\partial t} < 0$ and $\frac{\partial^2 p}{\partial t^2} < 0$.

After some time, with the movement of the pressure disturbance away from the area, one has $\frac{\partial^2 p}{\partial t^2} > 0$ and finally $\frac{\partial p}{\partial t} > 0$

The curve of fig. 28 expresses the described sequence in time and particularly the inversion of sign of $\frac{\partial p}{\partial t}$ which is very likely to follow large negative tendencies.

In reference to the actual application of (5.2.I.) it has to be stressed that the method is based on cases of increasing sea level; the use of (5.2.I.) should therefore be limited to situations in which meteorological fields are favourable to the phenomenon. This is true whenever at least one of the four pressure differences in space, P_1-P_2 , P_3-P_4 , $P_5\,P_6$, P_7-P_8 , is positive.

When the meteorological component of the tide is computed by means of the (5.2.I.) one has to add a suitable estimate of the astronomical tide and a constant value to pass from the present reference level to that of 1897.

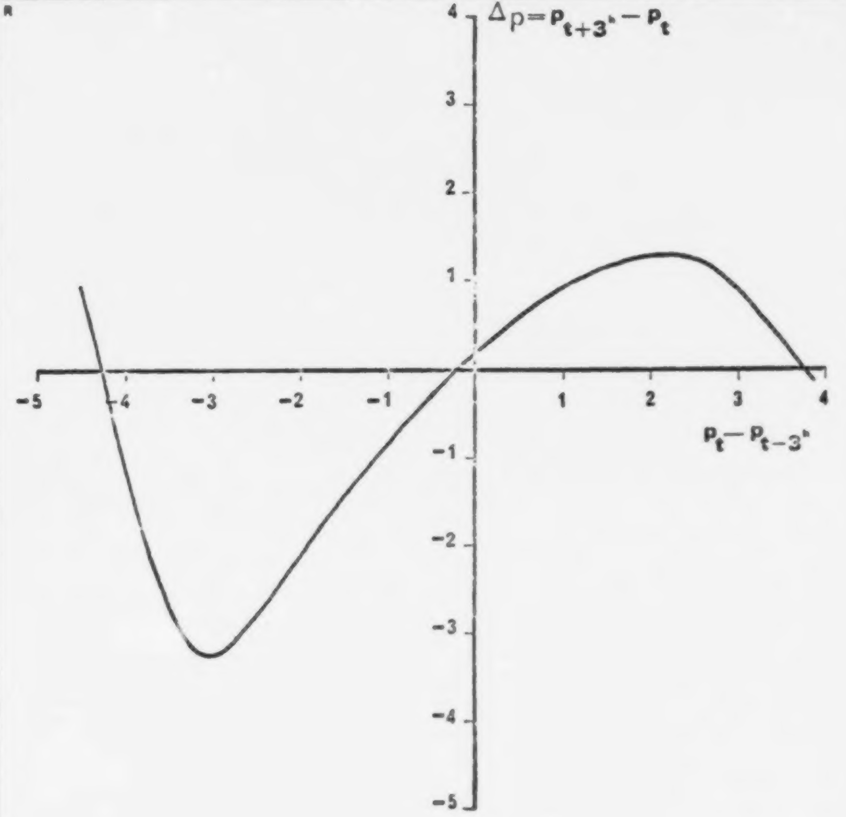

Fig. 28 - Graphical relationship between the variation of pressure during the last three hours and the same quantity relative to the subsequent three hours.

variations of the sea level may be necessary. These reasons, and also the important economic consequences of the high waters, call for a probabilistic approach for deciding whether a "warning" should be given or not.

7.I - Decision under risk

One refers to "decision under risk" when a choice is possible among a number of actions, each of them leading to one of a set of possible specific outcomes, each outcome occurring with a known probability (I6).

Situations of this type may be represented by the so called "payoff" matrix

$$
(7.I.I.) \qquad \begin{array}{c|cccc|}
 & S_1 & S_j & & S_n \\
A_1 & a_{1,1} & & & a_{1,n} \\
A_i & & a_{i,j} & & \\
 & & & & \\
A_m & a_{m,1} & & & a_{m,n}
\end{array}
$$

The states of nature S_j stand for the various possible alternatives characterized by the relative probabilities p_j . Each state of nature is associated with a column-vector of components $a_{i,j}$ which express the consequence (in monetary terms) of the decision i and the occurrence of the state of nature j . In the problem under consideration a first schematization may involve two alternatives:

S_I Actual sea level less than II0 cm.

S_2 Actual sea level equal or greater than II0 cm.

The possible actions are:

A_I No warning is issued.

A_2 A "high water" warning is issued.

The corresponding payoff matrix is

$$\begin{array}{c|cc} & S_1 & S_2 \\ \hline A_1 & a_{1,1} & a_{1,2} \\ A_2 & a_{2,2} & a_{2,2} \end{array}$$

Although a unique general rule for the selection of the optimal decision does not exist, in similar cases the PASCAL criterion is the most used.

For each decision the "operational gain" g_i is computed

(7.I.2.) $$g_i = \sum_{j=1}^{2} p_j \cdot a_{i,j}$$

and the action is chosen for which g_i is maximum. This criterion is particularly suitable for an operational service dealing with a recurrent decisional problem. As a matter of fact assuming that the number of cases increases, the operational gain g_i of the action A_i is the average gain corresponding to that action. This leads to the possibility of evaluating the utility of the warning system.

If C is the cost of the "alarm" (cost of the warning and of the measures which are taken) fD and D the consequences (in monetary terms) associated with the state of nature S_2 with and without alarm respectively $(I - f) > 0$ is the fraction of D which is saved by the warning) the payoff matrix is

(7.I.3) $$\begin{array}{c|cc} & S_1 & S_2 \\ \hline A_1 & 0 & -D \\ A_2 & -C & -fD-C \end{array}$$

The operational gains are

(7.I.4) $$\left\{\begin{array}{l} g_I = 0 - p_2 D \\ g_2 = -p_I C - p_2 (fD + C) \end{array}\right.$$

The knowledge of all parameters involved in (7.I.4.) would allow the computation of g_1 and g_2 and the selection of the optimal action.

The PASCAL criterion has been extended by BAYES (17) who introduced the concept of "Decision Rule", a prescription which allows arriving at either A_1 or A_2 on the basis of the information at one's disposal.

In our case a possible form of a generic decision rule D_i is

$$K \geqslant K_i \longrightarrow A_2 \qquad (7.I.5.)$$

$$K < K_i \longrightarrow A_1$$

The index k , in the simplest case in which only one forecasting method is available, can be defined by

$$K_{t+3^h} = (\Delta h)_{t+3^h} + (\Delta T)_{t+3^h} + 22 \text{ cm} \qquad (7.I.6.)$$

where the subscripts stand for the time to which the various quantities are referred and ΔT is the astronomical tide.

K_i is a proper threshold value.

One has to introduce the two following probabilities:

$P_1(A_1,D_i)$: Probability that if S_1 is true, the computed value of the index K is such that the decision rule D_i prescribes A_1.

$P_2(A_2,D_i)$: Probability that, if S_2 is true, the computed value of the index K is such that the decision rule D_i prescribes A_2.

The "payments" of D_i are then

$$u(D_i,S_1) = P_1(A_1,D_i) \cdot a_{11} + \left[1 - P_1(A_1,D_i)\right] \quad a_{21} \qquad (7.I.7.)$$

$$u(D_i,S_2) = P_2(A_2,D_i) \cdot a_{22} + \left[1 - P_2(A_2,D_i)\right] \cdot \quad a_{12}$$

and the corresponding payoff matrix is

$$\begin{array}{c|cc} & S_1 & S_2 \\ \hline D_1 & u(D_1,S_1) & u(D_1,S_2) \\ \cdot & \cdot & \cdot \\ D_i & u(D_i,S_1) & u(D_i,S_2) \\ \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \end{array} \qquad (7.I.8.)$$

It should be stressed that the $u(D_i, S_j)$ include the information used in the computation and use of the index K

Calling P_j^* the "a priori" probabilities of the states of nature S_j, following BAYES one has to pick out the decision rule which maximizes the operational gain

(7.I.9.) $$g = P_I^* u(D,S_I) + P_2^* u(D,S_2)$$

7.2 - Determination of P_I^* and P_2^*.

Whenever the conditions are fulfilled for the application of 5.2.I., the probability that an above-average sea level occurs, is rather large. Thus an approximate estimate of the frequency of the state of nature S_2 can be derived from the ratio between the number of high waters and the number of days in which an above-average sea level has been recorded (if the I897 zero reference is assumed, the average sea level is 22 cm). Noting that the meteorological conditions do not show on the average any preference with respect to the increase or decrease of the sea level (the mean annual sea level in the last years has not appreciably departed from 22 cm) the frequency of S_2 may be given by

(7.2.I.) $$f_2 = \frac{n_{>110}}{m \cdot \frac{365}{2}}$$

where $n_{>110}$ is the number of high waters occurred during m years. The available data indicate that the number of days characterised by above-average daily mean sea level is about 365/2.

This estimate is based on the decade I959-I968. As a matter of fact, a consideration of all high waters at our disposal, may lead to erroneous estimates (underestimate) of f_2 due to the ground subsidence.

It has been found that

$$f_2 = I,5\%$$

It is noteworthy that this value was obtained on the base of a relatively small sample (I0 years); its significance should therefore be confirmed by an analysis of a more extended period. On the assumption that probabilities and frequencies may be taken to be equal one has

$P_I^* = 0,985$ $P_2^* = 0,0I5$

7.3 - Determination of $P_I(A_I,D_i)$ and $P_2(A_2,D_i)$.

The 7 cases of I968 used to test the experimental model have been taken into consideration. The root mean square error μ of the predicted with respect to the observed sea level turned out to be I6 cm.

With the intent of computing P_I and P_2 one has to define quantitatively two values of the sea level which are suitable to represent in this problem S_I and S_2.

Considering that interest is focused on the first threshold value for which the warning is issued II0 cm has been assumed as the characteristic value corresponding to S_2. As far as S_I is concerned, 65 cm has been chosen, namely the mean value between II0 and 22 cm. On the assumption of random errors, introducing the error probability distribution functions centered in 65 cm and II0 cm,

$$f(\xi_1) = \frac{1}{\mu\sqrt{2\pi}} \cdot \exp\left(-\frac{1}{2} \cdot \frac{\xi_1^2}{\mu^2}\right)$$

where $\xi_1 = K - 65$ and

$$f(\xi_2) = \frac{1}{\mu\sqrt{2\pi}} \cdot \exp\left(-\frac{1}{2} \cdot \frac{\xi_2^2}{\mu^2}\right)$$

where $\xi_2 = K - 110$, one has

$$P_1(A_1, D_i) = \int_{-\infty}^{K_i} f(\xi_1)\, d\xi_1$$

(7.3.I.)

$$P_1(A_2, D_i) = \int_{K_i}^{+\infty} f(\xi_2)\, d\xi_2$$

The following ten decision rules have been considered

D_I $(K_I = 50)$	D_2 $(K_2 = 55)$	D_3 $(K_3 = 60)$	D_4 $(K_4 = 65)$
D_5 $(K_5 = 70)$	D_6 $(K_6 = 75)$	D_7 $(K_7 = 80)$	D_8 $(K_8 = 85)$
D_9 $(K_9 = 90)$	$D_{I0}(K_{I0} = 95)$	$D_{II}(K_{II}=I00)$	$D_{I2}(K_{I2}=I05)$
$D_{I3}(K_{I3}=II0)$	$D_{I4}(K_{I4}=II5)$	$D_{I5}(K_{I5}=I20)$	$D_{I6}(K_{I6}=I25)$
$D_{I7}(K_{I7}=I30)$	$D_{I8}(K_{I8}=I35)$	$D_{I9}(K_{I9}=I40)$	

The computed values of P_1 and P_2 are reported in the next tables

$P_1(A_1,D_1)$	0.173	$P_1(A_1,D_8)$	0.892	$P_1(A_1,D_{15})$	I
$P_1(A_1,D_2)$	0.267	$P_1(A_1,D_9)$	0.941	$P_1(A_1,D_{16})$	I
$P_1(A_1,D_3)$	0.376	$P_1(A_1,D_{10})$	0.970	$P_1(A_1,D_{17})$	I
$P_1(A_1,D_4)$	0.500	$P_1(A_1,D_{11})$	0.985	$P_1(A_1,D_{18})$	I
$P_1(A_1,D_5)$	0.624	$P_1(A_1,D_{12})$	0.993	$P_1(A_1,D_{19})$	I
$P_1(A_1,D_6)$	0.733	$P_1(A_1,D_{13})$	0.997		
$P_1(A_1,D_7)$	0.827	$P_1(A_1,D_{14})$	0.999		

$P_2(A_2,D_1)$	~ I	$P_2(A_2,D_8)$	0.941	$P_2(A_2,D_{15})$	0.267
$P_2(A_2,D_2)$	~ I	$P_2(A_2,D_9)$	0.892	$P_2(A_2,D_{16})$	0.173
$P_2(A_2,D_3)$	0.999	$P_2(A_2,D_{10})$	0.827	$P_2(A_2,D_{17})$	0.108
$P_2(A_2,D_4)$	0.997	$P_2(A_2,D_{11})$	0.733	$P_2(A_2,D_{18})$	0.059
$P_2(A_2,D_5)$	0.993	$P_2(A_2,D_{12})$	0.624	$P_2(A_2,D_{19})$	0.039
$P_2(A_2,D_6)$	0.985	$P_2(A_2,D_{13})$	0.500		
$P_2(A_2,D_7)$	0.970	$P_2(A_2,D_{14})$	0.376		

7.4 - Operational gains.

According to 7.1.7 and 7.1.9 the operational gain of decision rule D_i is then

$$g_i = P_1^* \cdot u(D_i,S_1) + P_2^* \cdot u(D_i,S_2) =$$

$$= P_1^* \left[C \cdot P_1(A_1,D_i) - C \right] + P_2^* \left[(D - f \cdot D - C) \cdot P_2(A_2,D_i) - D \right] \qquad (7.4.1.)$$

If one assumes, as an example, in arbitrary units of money

C = cost of the alarm = 5;

D = consequences of the high water without alarm = 1000;

fD = consequences of the high water with the alarm = 900;

the cost to benefit ratio is 5%.

Introducing in 7.4.1. the values of $P_1(A_1,D_i)$, $P_2(A_2,D_i)$, P_1^* and P_2^* determined in subsections 7.2 and 7.3 one obtains:

g_1	-17.65	g_7	-14.47	g_{13}	-14.30
g_2	-17.15	g_8	-14.18	g_{14}	-14.46
g_3	-16.64	g_9	-14.01	g_{15}	-14.62
g_4	-16.07	g_{10}	-13.97	g_{16}	-14.74
g_5	-15.45	g_{11}	-14.02	g_{17}	-14.85
g_6	-14.95	g_{12}	-14.14	g_{18}	-14.92
				g_{19}	-14.96

In fig. 29 the variation of the operational gains as function of the decision rule is shown. With the assumed cost-benefit ratio the alarm service becomes advantageous starting from decision rule D_4 on. The optimal decision rule is

$$K \geq 95 \longrightarrow A_2$$

$$K < 95 \longrightarrow A_1$$

The associated gain, assuming as the zero of the scale the gain corresponding to the absence of any alarm service, is

$$g_{10} - g_{\infty} = -13.97 - (-15) = -1.03$$

The local Authorities of Venice are in the best position to provide reasonable estimates of the economic parameters C, D, f and to apply in the most realistic way the considerations given in this section.

8 - CONCLUSION

The study of several cases of high water at Venice from a statistical point of view indicates a frequency distribution with a maximum in November-December, strictly related to the frequency of cyclonic developments over northern Italy and the northern Adriatic.

A successive analysis of large scale situations associated with all cases of high water which have occurred since the beginning of the century leads to the conclusion that the most frequent configurations are those characterized by a deep depression over western Europe, often concomitant with a blocking high pressure area over eastern Europe. The said large scale features are amenable to prediction 24 hours in advance.

A more detailed study in space and time of surges at Venice shows that the phenomenon may be interpreted as the result of one or more different causes:

1) strong southeasterly winds over the Adriatic;
2) strong southerly flow over Ionian and adjacent seas;
3) Easterly winds over northern Adriatic;
4) direct effect of atmospheric pressure.

An empirical equation has been determined which is capable of providing predictions of the sea level as a function of atmospheric pressure data. Referring to the problem of sea level prediction a simple technique has been developed to obtain time extrapolated pressure values three hours in advance.

Finally, a method has been proposed based on the theory of decisions under risk which allows rationalization of the alarm system. Taking into account the overall frequency of surges, the root mean square error of predictions and the economic parameters involved, the method provides the optimal decision rule to be used to decide whether a warning is to be issued or not.

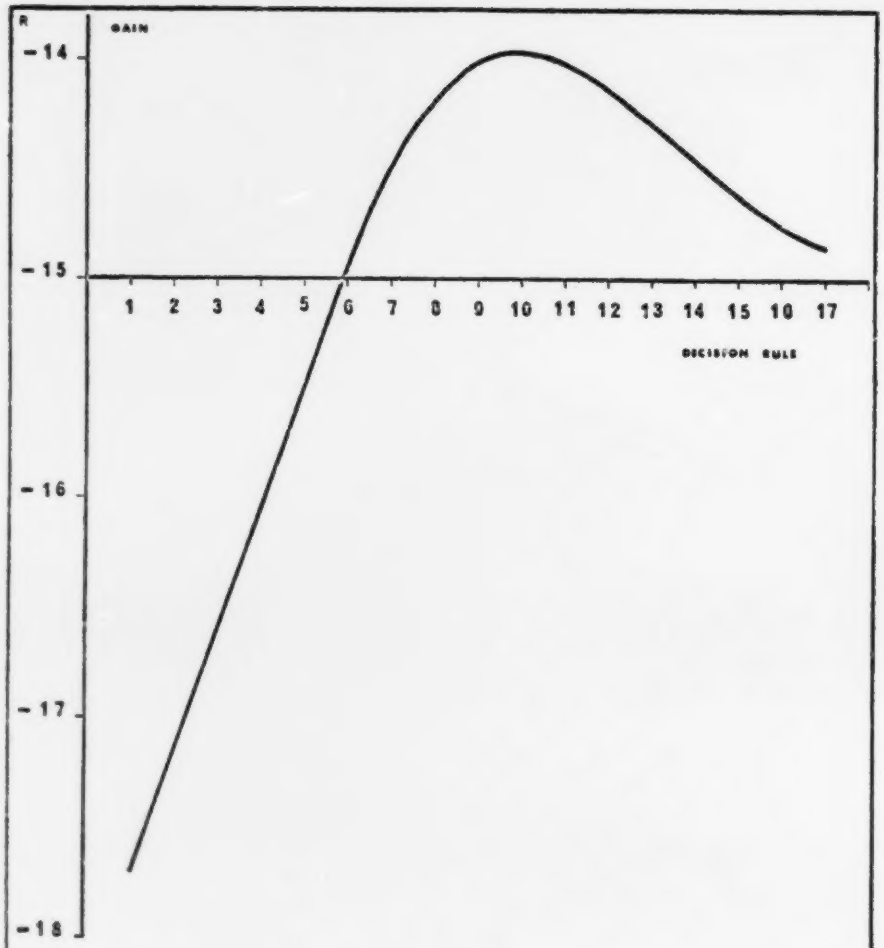

Fig. 29 - Operational gain as a function of decision rules.

A NUMERICAL MODEL OF THE ADRIATIC SEA FOR THE STUDY AND PREDICTION OF SEA TIDES AT VENICE

(Lavoro eseguito per il "Comitato di
Studio dei Provvedimenti a Difesa della
Città di Venezia" del Ministerio LL.PP.)

by C. Finizio, S. Palmieri
and A. Riccucci

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Consiglio Nazionale Delle Ricerche,
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Piazzale Luigi Sturzo, 31
00144 - ROMA - EUR.)

SUMMARY

The report deals with the application of a physical mathematical model of the Adriatic Sea to the problem of predicting the sea level variations at Venice.

First of all, the motion equations are considered, including the wind stress and bottom friction. Taking into account the peculiar topography of the region, an undimensional model of the Adriatic Sea is formulated.

Afterwards, the problem of the integration of the basic equation is faced. The conditions for the computation stability are determined; a first test of the model is carried out by computing the variation in time of some fundamental quantities like the mass and energy of the basin.

Thereafter, the main effects due to the geometry of the basin are studied by using ideal "wind quanta". Two main periods are found (T1 29 hours and T2 11.5 hours), respectively related to the depth and length of the basin and to the depth and location of the Otranto channel gap. Agreement is found between the results of the model and those obtained by means of the classic hydrodynamics. Next applications of the model to actual cases of sea level rise at Venice follow. In this reference, a problem of primary importance is the determination of the space and time distribution of wind. The problem is solved disregarding the measured winds at coastal stations and expressing the wind as a function of the pressure field. At last, on the basis of a critical analysis of the results, some considerations on the predictibility of the phenomenon and suggestions for future developments are offered.

INDEX

1. Summary
2. Introduction
3. Formulation of a physical model of the Adriatic Sea
3.1 Equations of motion
3.2 Channel model
3.3 Wind stress
3.4 Friction at the bottom
3.5 Considerations on the prediction model and boundary conditions
3.6 Computational stability of the model
3.7 Formulation of the finite difference equations
4. Verification of the system's stability
4.1 Space integral extended over the Adriatic basin
4.2 Time integrals at a point (Otranto channel)
4.3 Mass conservation
4.4 Energy conservation
5. Experiments to study the effects of the basin's configuration
5.1 Constant geometry
5.2 Inclined plane bottom configuration
5.3 Inclined plane, Southern Adriatic hole and narrowing of the Northern Adriatic
5.4 Otranto channel bottle-neck and actual configuration

6. Application of the model to real cases, using the actual wind distribution in time and space

6.1 Wind distribution in space and time

6.2 Determination of the model's coefficients

6.3 Some general considerations

6.4 Initial calibration of the model

6.5 Results of the application of the model to actual cases

6.6 Analysis of results in the light of the model's limitations

7. The prediction problem; suggestion for further development of the study

8. Conclusion

Acknowledgements

Bibliography

AN OBJECTIVE METHOD FOR PREDICTING HEAVY PRECIPITATION

by S. Palmieri and C. Finizio
(Italy)

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Consiglio Nazionale Della Ricerche,
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Piazzale Luigi Sturzo, 31
00144 - ROMA - EUR.)

SUMMARY

A synthesis is made of the flood situations occurred in a decade. Particularly, the general features are examined of the horizontal distribution of heaviest precipitation in a system moving with the disturbance, and the intensities of phenomena are correlated with the conditions of the atmosphere along the vertical.

The results of this synthesis are utilized as a basis for the realization of an objective prediction method in which the prediction itself is seen as a function of the connected economic and operational factors.

A MODEL OF DETAILED ANALYSIS

THE METEORLOGICAL CONDITIONS OVER ITALY DURING PERIOD 31ST AUGUST - 4TH SEPTEMBER 1965

by I. Visconti, M. Capelli and A. Fagioli
(Italy)

INTRODUCTION

The thunderstorm phenomena and the rains occurred in Italy early in September 1965 seem to deserve, because of their special intensity, extent, and persistence, a detailed analysis. This, because the current synoptic analysis does not appear suitable for detecting and describing those discontinuities which can account for the phenomena observed, and which have given a precipitation total amount equal, in the average, to some 30% of the yearly total, in four days only.

In the first part of the following pages the evolvement of single phenomena will be examined minutely along three consecutive steps, and each minute, or detailed, analysis will be preceded by an outline of the situation such as it appears at normal synoptic scale. In the second part, to complete the picture of the detailed analysis, the distribution of precipitation will be described, such as it results from the data of the very dense network of pluviometric stations depending on the *Ministero dei Lavori Pubblici*. A comparison between the perturbations described and the surveys of the atmospherics network data, which comparison points out the importance of such information service also from the operative point of view, will finally conclude the work.

The detailed analysis, that has been carried out applying the concepts and the work criteria of the mesoanalysis, has required use of 150 « individual station time section cards » relating to as many stations of the *Servizio Meteorologico A.M.* (1), besides the current synoptic charts. Figs. 26 and 27 report, as examples, the individual station time section cards of Passo Resia, Monte Spluga, Roma-Fiumicino, and Foggia-Amendola stations. As it can be remarked from these figures, a card gives an immediate general picture of all that has occurred at a certain site, allows identification of singularities of the various meteorological variables and a direct comparison with what has been recorded in the neighbouring areas.

The work method consists essentially in iterated comparisons between the results of the synoptic analysis and those obtained by investigation of the singularities recorded in the individual station time section cards; and this allows, through a series of successive approximations, to arrive at the detailed analysis desired (2). The minute and enduring work of identification of the perturbations has been accomplished, step by step, by the single analyzers, independently of one another. After accurate criticism and discussion of the results they have agreed with one another on the most satisfactory solution. Such type of analysis having been repeated and checked several times at months' intervals, it can finally be stated that the results obtained have a very high degree of exactness and objectivity.

This work constitutes another example of the importance of orographic effect chiefly in the precipitation field and is as well a confirmation of suitableness of frontal analysis for Italy, as such analysis can well account for the phenomena observed from 1st to 4th September, 1965; however the detailed analysis can point out complexity of fronts and variability of their features when they move from an area to another. In fact the fronts, rather than constituting a continuous perturbed line, appear, as it will be described later on, as more or less irregular sets of "families", or groups, of perturbations usually showing up in the form of bunches, sometimes broken into "segments".

The schemes adopted in describing the fronts relating to this period cannot, obviously, be deemed as being valid for all fronts moving across Italy, but they can provide a possible explanation for the difficulties met with in carrying out weather analysis and forecasting over Italy. These schemes should be taken into proper account when discussing the effects of the single perturbations, and phenomena associated, which can be detected at synoptic scale in the current operative analysis. It is therefore thought that this work can also be of significant didactic usefulness, considered the difficulties encountered for distinguishing the detailed structure of the perturbations.

1. GENERAL SYNOPTIC PATTERN OF THE CIRCULATION OVER EUROPE ON 31ST AUGUST 1965

1.1 *31st August 00 GMT* (Fig. 1)

A wide frontal depression, in advanced development stage, affects northwesterly Europe. Cold front B of this system lengthens from Ireland and Great Britain to North Sea, delimitating a large block of polar air, better defined at middle and upper levels, that is moving southward, however the warm front is weak and little active. A northwesterly flow of atlantic polar air can be remarked ahead of cold front B, running as far as the eastern Mediterranean.

Another element, important for the system evolvement, is limit A, that is found in a frontogenetic zone at confluence of the atlantic polar air and the warm moist air masses dwelling on the northern edge of an upper dynamic anticyclone centred over Morocco.

At surface however a depression extends with a weak trough from the Sahara desert as far as Spain and northern Italy. Contemporaneous with this situation remarkable thunderstorm phenomena occur over northern Italy.

1.2 *31st August 12 GMT* (Fig. 2)

In relation to the southward motion of the polar air masses (a closed —28 °C isotherm can be noticed on the 500 mb contour lines) an upper trough extends over western Europe, deepening.

Over the Mediterranean from Iberia to Italy at upper levels the streams take on a southwesterly direction, with weak cyclonic curvature and development of small cold waves rapidly moving from the Pyrenees to the eastern Alps. To this evolvement at upper levels corresponds a remarkable and speedy frontogenesis of limit A that becomes a front rapidly moving southwards in its western part. Concomitant with this frontogenesis a cyclogenetic process starts at surface with formation of a pressure low over the western Riviera and another over Switzerland.

Over Italy the surface pressure low favours the weak warm air flow from Africa, and this air gets remarkably moist during passage on the sea. The thunderstorm phenomena over the northern regions extend also toward the central ones. Such activity persists during all the night hours on following 1st September.

2. DETAILED ANALYSIS OF THE THUNDERSTORM ACTIVITY DURING 31ST AUGUST AND EARLY HOURS ON 1ST SEPTEMBER, 1965

2.1 On August 31st the conditions over Italy have been characterized by thunderstorm activity that has concerned the northern and central departments, and, specially persistent and widespread, Liguria and Toscana (1); it has showed as short lasting local activity of large stationary cells and as moving instability lines; nine of the latter have been singled out and have been indicated by letters from *a* to *i*.

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(1) see Fig. 28: map of the Italian regions.

2.2 The major causes for this remarkable thunderstorm activity might be:

a) the instable or moist-labile initial structure of the atmosphere which appears to be very rich with water vapour from surface to upper levels;

b) the systematical feeding of very moist and warm air into layers from surface up to the 2 500 m level, operated by the weak southern stream;

c) the persistent cooling in the 2 500-4 000 m layer, produced by the weak western stream;

d) the presence of reliefs windward the streams of the low layers.

It must be remarked that the above-indicated temperature decreases in the upper levels must be interpreted, in the light of the detailed analysis, as a series of successive advective pulses of cold air at the medium levels, each of such pulses being connected with a thunderstorm line or cell.

Figures 11, 12 and 13 report the isochrones of the tunderstorm lines and location of the stationary cell. A brief outline of these is given.

2.3 *Stationary cells*

Of these cells four of the thunderstorm type have been individualized, and indicated by letters *a*, *b*, *c*, and *d*; one of the rainy type is indicated by *e*. The first cell develops in the pre-Alpine zone from 00 to 06; the second cell *b* develops in the Genova Gulf from 01 to around 05; the third cell *c* develops over the Ligurian Gulf and the regions of northern and central Tyrrhenian versant from 15 to around 23; the last one, *d*, over Toscana from 01 to 03. The rain amount given by the third cell *c* at Genova and Pisa is remarkable (50 and 43 mm, respectively).

The rainy zone *e* concerning Trentino from 02 to 06 and the short rainy front *f*, expanding from the *a* cell over northern Adriatic can be considered as extensions of the thunderstorm cell *a*.

2.4 *Moving instability lines*

Three of these lines have been individualized and indicated by letters *g*, *h* and *i*. The first line to appear is the *g* one, that has a limited extension; it crosses Toscana, Umbria and Abruzzi from 07 to 16 and gives, locally, weather for 3-4 hours. More important has appeared line *h*, that originates over Liguria around 09, is found over Friuli and Emilia by 17 and damps out over Marche around 21-23. This line can be considered as being a cold front and is evidenced by the decrease in temperature recorded at the mountain stations, by radiosonde observations, and by presence of a thermal trough on the 850 mb contour lines. Last line, *i*, concerns the coast of Toscana, Lazio and Napoli zone on September 1st from 00 to 06.

The orographic effect is confirmed by the fact that the records of the *Servizio Meteorologico A.M.* meteorological stations show that the rain amounts connected with the single perturbations give the highest values (from 40 to 50 mm) in Lombardia, Liguria and northern Toscana, and these figures are those relating to the stationary cells.

3. SYNOPTIC GENERAL PATTERN OF THE CIRCULATION OVER EUROPE ON 1ST AND 2ND SEPTEMBER 1965

3.1 *1st September 00 GMT* (Fig. 3)

The upper trough associated with the main pressure low continues to move southwards deepening. The cold polar air mass extends as far as the Bay of Biscay, giving birth to a well-pronounced thermal trough. The surface pressure low over northern Europe is filling up, while the cyclogenesis over the Mediterranean develops on. The northeasterly section of front B has weakened. The low pressure belt, connected with the Sahara depression, is the seat of pressure lows, among which the one over the Genova Gulf is well evident. The flow of humidified air from Africa is therefore reinforcing. It must be remarked that over Italy when warm and moist air in the low layers underflows polar air at upper levels, development of most perturbed weather is always connected.

While over central Italy the thunderstorm phenomena described keep on, over northern regions action starts of front A, that is already crossing the surface pressure low over the Genova Gulf.

3.2 *1st September 12 GMT* (Fig. 4)

The upper pressure low which on August 31st was found over the North Sea continues moving southwards, unchanged in intensity, together with the cold air, and its central portion reveals its vortex character more and more markedly. The cyclogenesis over the Genova Gulf continues to intensify extending up to the 3-4 km level as a closed circulation. Further, a frontal wave has formed on the northern end of front B that, on turn, is crossing the surface pressure low. Over Italy the post-frontal cold air of front A is rapidly replaced by a new flow of warm and moist air which constitutes the warm sector of front B. The warm front that delimitates the sector, however, is not, how it usually happens for the warm discontinuities over Italy, well-identifiable in the field of the surface-recorded elements. A marked instability of the air masses and the strong cyclonic curvature of upper streams contribute remarkably for formation of thunderstorm lines over Tyrrhenian and Liguria, and for development of intense, persistent and extended thunderstorm activities which superimpose themselves on the frontal ones.

3.3 *2nd September 00 GMT* (Fig. 5)

The cyclone over the Genova Gulf has furtherly developed: at upper levels, it has reached the high layers of the atmosphere reinforcing the vortex come from north in which it merges.

At surface this cyclone continues deepening after passage of front B, because of approaching of new cold front C. It has formed in the English Channel zone about 24 hours before, at little distance from front B, the track of which it has followed. This front, too, is preceded, over Italy, by a pronounced pulse of warm air, which has already replaced the post-frontal cold air of B few hours later.

As it can be remarked from the maps, fronts B and C over Italy act upon a well-defined flow of southerly warm air, which has always been intensifying till reaching central-eastern Europe. The wave-shaped warm front ovr these regions represent the farthermost limit, at surface, of the above-mentioned warm flow.

Front B shows up over Italy with strong intensity; it is preceded and followed by instability lines and squall lines with widespread thunderstorm phenomena which have concerned mainly Liguria, central regions and the northeasterly Po Valley.

3.4 *2nd September 12 GMT* (Fig. 6)

A strong centre of cyclonic vorticity at 500 mb has concerned southern Spain and the Alboran Sea, favouring an apparent regression of the cold depression. From the central cold air mass of this depression another cold pulse separates and then from the Gulf of Lions it tendes to move over Sardegna. The Genova Gulf cyclogenesis begins the final stage and the surface low begins to fill up.

The well southerly direction of the streams and the orographic pattern are so that a new cyclogenesis occurs in Austria, in the lee of the Alps.

Front B is washing out over the southernmost regions. Front C is active chiefly over Toscana, and the air mass of the preceding warm sector appears to be very instable.

4. THE FUNDAMENTAL FEATURES OF THE FRONTAL PERTURBATIONS, SUCH AS THEY RESULT THROUGH THE DETAILED ANALYSIS

The five frontal perturbations, indicated by letters A, B, C, D, and E, do not result to be constituted, according to the detailed analysis — as it will be specified later on — of a continuous line, but of more or less regular sets of families or groups of perturbations usually in the form of "bunches".

The perturbations break in fact into "segments", sometimes at different levels; many times they show up in groups concerning several zones contemporarily.

It is deemed that the complex structure of these perturbations is due mainly to the following factors:

a) the air masses involved are different and undergo rapid transformations;

b) their motions occur, for a great part, in a southerly mean flow;

c) the orography and the sea-land interaction play a very important role;

d) the high temperatures at surface allow, given the season, high values of specific humidity;

e) the rather high altitude of the tropopause (12 km about).

5. DETAILED ANALYSIS OF FRONT A

5.1 *Front A is a cold perturbation affecting low and medium troposphere*

From examination of the individual station time section cards mentioned in the introduction, front A results to be composed of two pulses A-1 and A, 3-8 hours spaced in time. Figures 14, 15, and 16 report the isochrones of these two pulses. A-1 is divided into two segments: one concerns the northeasterly Italian regions, the other affects central Italy, eastern Liguria, and Emilia. However, A is divided into three well-separated segments: the first concerns the Venezie, the second affects Toscana, Umbria and Marche, the third concerns the northeasterly part of Sardegna.

Further, on 1st September around 11 hours, northern segment of a stops moving easterly and starts a backward motion toward northwest, and it can be tracked as a warm wave for 2-3 hours, (A_c).

5.2 *Some features of the two cold pulses A-1 and A*

The features of the two pulses change depending on the regions crossed. A-1, for example, is associated with initial phase of decreasing pressure on Lombardia, stationary pression on Veneto, and pressure already decreasing on Sardegna. Temperatures over the plains do not change noticeably, while they decrease over highgrounds and at high altitudes.

Precipitation is abundant almost everywhere; to the north, precipitation given by A-1 merges in the precipitation given by A and altogether they last 8 to 24 hours (maxima on the central Alps and Venetian pre-Alps, with figures from 40 to 97 mm). No rains have been verified on southern and eastern Sardegna. On the Tyrrhenian central regions, on Marche and Abruzzi, the rains, even heavy, last altogether from 8 to 10 hours. Rain maxima are verified on Toscana, Lazio and Umbria, with figures from 40 to 80 mm.

Surface wind is prevailingly southern, weak over the northern regions, with local temporary reinforcements over the central ones (up to 30-50 knots).

6. DETAILED ANALYSIS OF THE LARGE PERTURBATION B

This perturbation is constituted of a cold front preceded by a warm pulse; the relating warm front however is not distinguishable but on the central Alps. From the examination of the individual station time section cards, perturbation B results to be formed of several pulses and segments: a warm front B_c^* on the central Alps; a pre-frontal pulse B-1, front B with B*, and the post-frontal pulses B+1, B_1^* and B_2^*.

6.1 Warm front B_c^* and following cold front B* affect the limited zone of the central Alps, in which they have been detected. The warm front shows up with an abrupt wind shift from N to S and with a sudden increase (a new degrees) in temperature (Figg. 18 and 26). Cold front B* too, shows up with an abrupt wind shift from S to N and sudden decrease in temperature. The rains connect with those of the other perturbations, however increasing in intensity on the perturbation passage.

6.2 *Pulse B-1* (Fig. 17)

This pulse is associated with the warm sector and gives heavy thunderstorms. It is divided into two segments: one concerns Liguria, the other affects Lazio, Marche and Friuli.

The wind, prevailingly southern, is irregular: light over the plains, generally strong over highground. However reinforcements over Liguria and gusts from western quadrants over the Tyrrhenian versant are verified. There where thunderstorm activity dwells, the wind shifts to the north for some hours.

Rains, thunderstorms and showers are weak and scarce on Friuli, they are however heavy but short-lasting on Toscana, elsewhere heavy rains are verified, which tend to connect with those or front A, mainly on high grounds; on certain sites the main duration reaches 15-24 hours. In the temperature field temporary decreases are remarked in correspondence to heavy precipitation.

6.3 *Front B* (Fig. 18)

Passage of B over Sardegna, Campania, Veneto, and Emilia is associated with lowest pressure values among those recorded during the whole cyclogenesis. Further, over some sites of central regions (mainly over the Tyrrhenian) and over western Sicilia presence of "mesohighs" is remarked; the temporary and sudden increases in pressure are associated with temporary decreases in temperature (above all in correspondence to heavy precipitation). Well-defined decreases in temperature are verified only over the northwestern regions and over Sardegna; over the remaining regions temporary decreases (even conspicuous) are connected with the precipitation maxima.

Over the Po valley wind is weak or light, around NE, with local reinforcements. Over the remaining regions wind is prevailingly light over plain, moderate to strong over highground and some sites of western Sicily. However, reinforcements and abrupt wind shifts to around W can be noticed chiefly over the Tyrrhenian. Over Sardegna the wind rotates definitely to W, after the front passage, as the individual station time section cards (not reported here) show.

On the Alps precipitation is abundant, specially on the central-eastern sections, but it is not distinguished from precipitation depending on the other perturbations. Weak rains occur only in the areas in the lee of the Apennines (duration 2-5 hours), on Molise, Puglie and the eastern part of Sicilia. Rains and moderate thunderstorm concern Sardegna (duration 3-7 hours). Elsewhere, specially on the Tyrrhenian versant, heavy rains and thunderstorms, however of irregular duration (from 2 to 12 hours), are verified.

6.4 *Segments $B+1$, B_1^* and B_2^** (Fig. 18)

$B+1$ affects Lazio and gives scarce rains (duration 2-4 hours); the pressure is already in the increasing; the wind, moderate, undergoes only some reinforcement from SW. B_1^* and B_2^* are cold pulses of minor importance, which concern Piemonte and bring about short-lasting periods of precipitation and moderate coolings.

6.5 The precipitation maxima associated with group B are verified on the central Alps, the eastern Alps and pre-Alps (with figures from 50 to 113 mm), the eastern coasts of Liguria and western portion of the Appennino Tosco-Emiliano (from 25 to 72 mm), on Lazio, Umbria, Marche and northern Abruzzi (from 40 to 100 mm), and, finally, on the western coast of Sicilia (from 30 to 64 mm).

7. FEATURES IN THE OUTLINE OF THE CIRCULATION OVER EUROPE DURING 3RD AND 4TH SEPTEMBER, 1965

7.1 *3rd September 00 GMT* (Fig. 7)

Cyclogenesis over Austria extinguishes and the surface low moves northwards filling up. The warm air continues flowing over the Balkan Peninsula and Germany; then, turning to the west, reaches the Netherlands and Denmark.

Italy is concerned with cold pulses C and D, that follow one after the other few hours spaced and show up more active over Lazio and Veneto.

A new cold front, E, forms over southern France in correspondence to a thermal trough in the medium layers and to strongest cyclonic curvature of the streams. It is well defined in the fields of cloudiness, precipitation and surface wind.

An upper cold trough begins concerning northern England.

7.2 *3rd September 12 GMT* (Fig. 8)

A third cyclogenesis develops over the English Channel and spreads rapidly at upper levels. This process is contributed by: the warm air connected with perturbation C, the cold air connected with trough over northern England, and the sea-land interaction.

Over Italy front C has washed out over the southern regions; D shows up active only over Toscana, Lazio and Marche; E appears to be well defined and it is intensifying in its southern portion.

7.3 *4th September 00 GMT* (Fig. 9)

The cyclogenesis over the English Channel furtherly develops and spreads to medium and high levels. The cold trough coming from north has brought about, at upper levels, a pressure low in the neighbourhood of Ireland.

The old cold depression over central Europe has been transforming, in its southern portion, into a trough spreading as far as Tunisia. On the eastern part of such trough the development zone for the perturbations is located. In fact, front E extends from eastern Tunisia to Yugoslavia, where it connects with C (the southern part of C has frontolized) through a series of frontal waves.

Over Italy front D has been very active over the central regions, and very weak over the southern ones; it is followed by a decrease in temperature; front E is well active only over Abruzzi, southern Tyrrhenian and western Sicilia, regions over which it is affected by the dynamical effect of upper streams and by the orography. It is associated with a remarkable decrease in temperature at upper levels.

7.4 *4th September 12 GMT* (Fig. 10)

The cyclogenesis over the English Channel has reached the maximum development stage, and at upper levels it forms one whole with the cold depression arrived from NW. Over central-eastern Europe the warm air flow does not appear to be fed any longer.

Over Italy post-frontal weather conditions are remarked after passage of E, the last important perturbation of the family.

8. DETAILED ANALYSIS OF FRONT C (Fig. 19)

8.1 This perturbation moves across the central-northern Italian regions beginning on 2nd September since 06 GMT, and it flows over them with a mean velocity of 18-20 km/h. Over the southern regions the effects of its passage are confined to weak phenomena over the Sicilia coasts. The perturbation appears in two segments: one concerns north Italy and northern Toscana, the other affects Sardegna, Lazio, Umbria and Marche. Between the two segments there are zones over which the perturbation is almost inactive. The northern segment brings about sky overcast and continuous, generally long-lasting, precipitation; the southern segment causes more intermittent precipitation of lesser total duration, frequently with thunderstorms.

8.2 The three major features of this perturbation are the warm flow, the pressure decrease before its passage and the wind profile. The warm flow causes a temperature increase of about 5° in 3-4 hours. This increase results well evident from the observations of the mountain stations, and from the «chrono-sections» derived from data of the radiosonde stations, whilst its existence does not appear as well evident from analysis of contour lines. Specially abrupt appears, on the other hand, the decrease in temperature immediately following the front passage.

In the pressure field C determines a new deepening of the Genova Gulf depression, that had begun to fill up after the front passage.

The effect of front C is evidenced by the barograms at the different Italian stations, which show decreases or stops in the increasing pressure graphs (see also (Figg. 25 and 26).

The wind with its abrupt rotation is the element which, more than any other, clearly indicates the front passage; it undergoes a counterclockwise deviation one to seven hours before the front passage, and furtherly shows a reinforcement whose maximum immediately precedes such passage. After this, the wind weakens or falls down.

8.3 The regions concerned, to larger extent, by precipitation, are: Lazio (with figures up to 45 mm), the eastern Riviera (with figures from 20 to 30 mm), the central Alps and Veneto (with figures from 30 to 60 mm).

9. DETAILED ANALYSIS OF PERTURBATION D (Figg. 20 and 21)

9.1 Perturbation D is preceded, as B and C have been, by a warm, however not very pronounced, pre-frontal pulse. This pulse is more evident in the low layers over the northwestern regions, whilst over the central and southern regions it results better evidenced through the upper data.

Perturbation D is constituted of a pre-frontal pulse, D-1, main cold front D, and a post-frontal pulse D+1. Cold front D concerns also the layers near surface. Associated with it goes on, over different sites, the cooling process already begun with front C. Pulse D-1 moves with a speed of 30 km/h and precedes D by a time interval ranging from 5 to 10 hours.

Post-frontal pulse D+1 follows the front after a 5-hour interval.

9.2 *Pulse D-1* (Fig. 20)

This pulse concerns the southernmost part of Sardegna and the central regions of the Peninsula. Its passage coincides with final phase of increasing pressure, and at many sites it is accompanied with «mesohighs» associated with heavy showers.

Temperature does not undergo, generally, long-lasting but only temporary decreases, and these are associated with the precipitation. The wind, prevailingly southerly, is strong only at the higher stations, with gusty reinforcements from around W

Over Sardegna D-1 is weak and associated with light or moderate precipitations (duration: 3-5 hours). This pulse shows an instability character over central Italy; it is strong over the Tyrrhenian and weak over the Adriatic versant. On the Tyrrhenian regions and the Apennines precipitation (rains and thunderstorms) is often heavy and, when isolated, it lasts 4-6 hours about; along the Adriatic coast however precipitation results to be light.

9.3 *Cold front D* (Fig. 20)

Almost everywhere this front brings about a cooling, which has already begun at some site on passage of C; the wind over the Alps shows southerly, strong, becoming temporarily northerly or westerly; over the Po Valley winds are light, often southeasterly; southerly light or moderate elsewhere, becoming westerly or quite northerly after the front passage.

Over the Alps precipitations merge in those of front. C; they result to be light on the plains of Piemonte and Emilia, Toscana, Sardegna and the central Adriatic versant. On the remaining regions of the Peninsula rains and thunderstorms occur which last, in the average, from 6 to 8 hours (on the Apennines they often connect with the previous ones, and there are rainy periods of 15-20 hours). On Sicilia light rain alternate with showers.

9.4 *Post-frontal pulse D+1* (Fig. 21)

This pulse is constituted of two segments, one which gets across Veneto with 4-10 hour persistent rains and the other which crosses the coastal zones of central Adriatic with 2 to 4-hour persistent rains.

9.5 The areas, on which precipitations associated with the above-described system D-1, D, D+1 have occurred in greater amount, result to be: Lazio and the Apennines (in the Abruzzi area) with maxima ranging from 50 to 80 mm; Friuli, with maxima from 40 to 56 mm; and the Apennines in the Liguria-Toscana area, with the maximum value of 20 mm.

10. FRONT E (Fig. 22)

10.1 This front concerns with its northern segment the western Alps it impacts on the 3rd September by 12 GMT. It gives persistent (from 5 to 8 hours) snowfalls on the higher and rains on the lower sites, then it extinguishes. Its southern segment reaches southern Sardegna on the 3rd September by 17 GMT, and spreading easterly

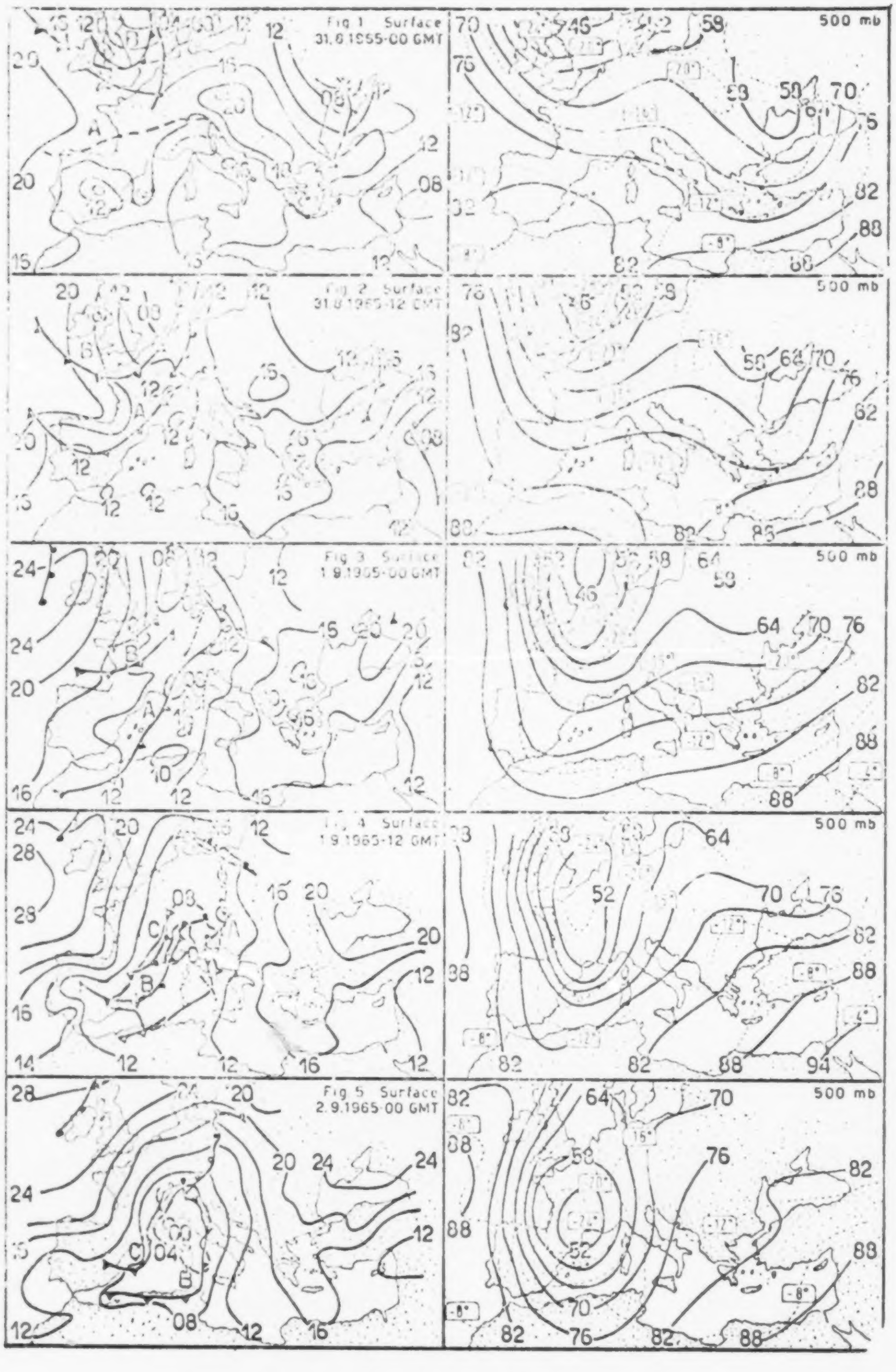
Fig 1 Surface 31.8.1965-00 GMT
500 mb
Fig 2 Surface 31.8.1965-12 GMT
500 mb
Fig 3 Surface 1.9.1965-00 GMT
500 mb
Fig 4 Surface 1.9.1965-12 GMT
500 mb
Fig 5 Surface 2.9.1965 00 GMT
500 mb

Fig. 1 - Fig. 5 - *Surface and 500 mb analysis*

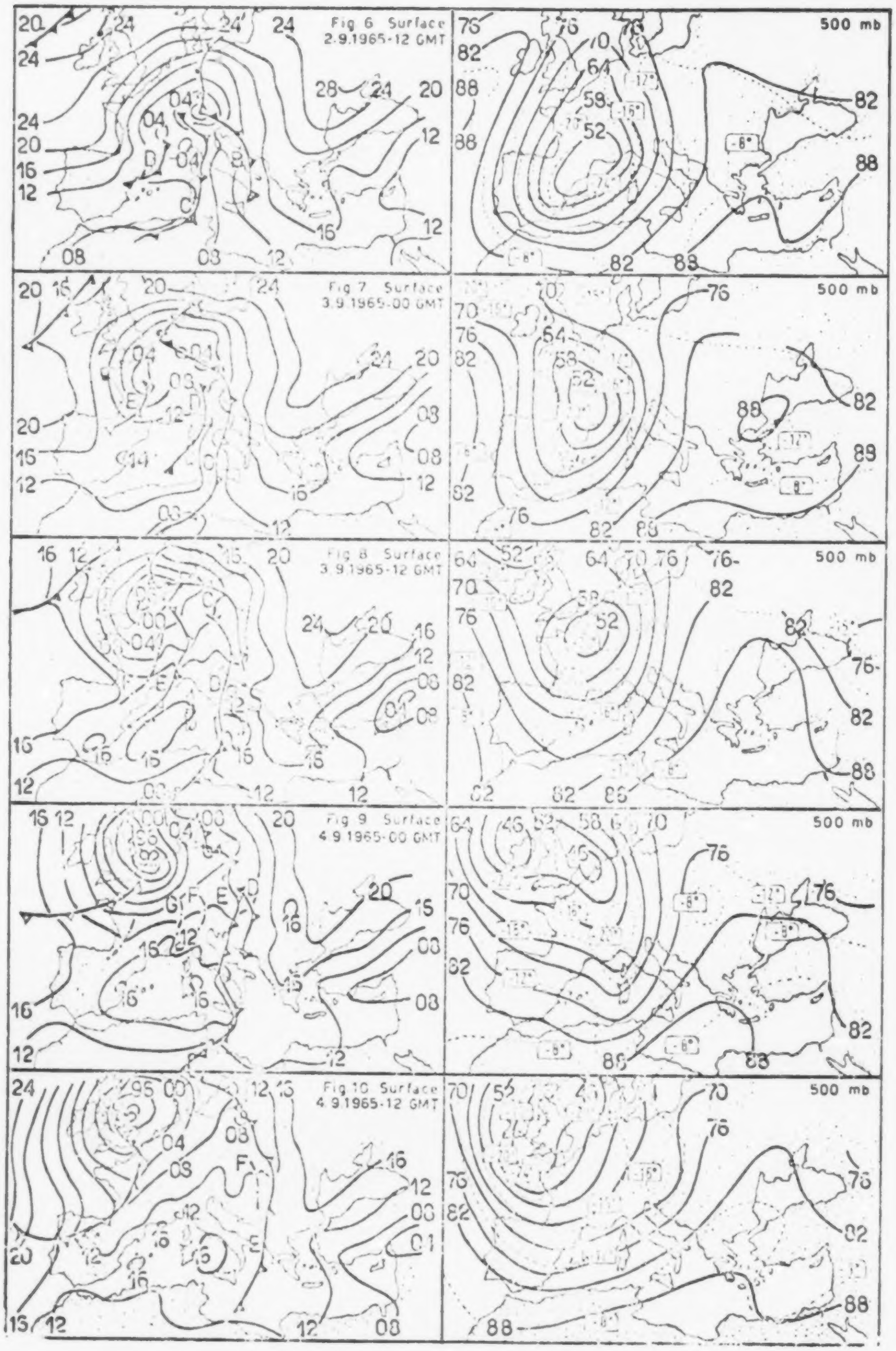
Fig 6 Surface 2.9.1965-12 GMT
500 mb
Fig 7 Surface 3.9.1965-00 GMT
500 mb
Fig 8 Surface 3.9.1965-12 GMT
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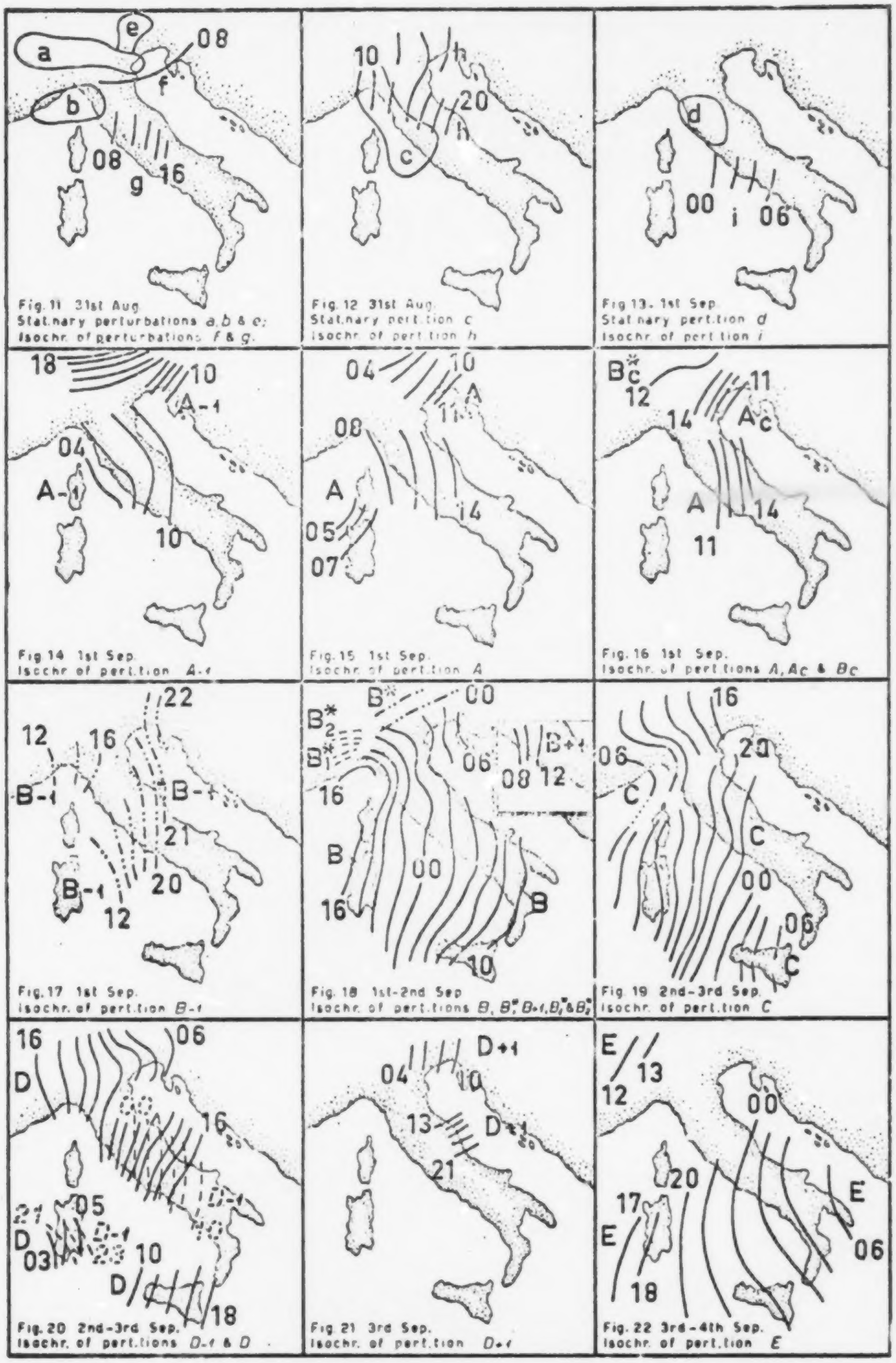
Fig 9 Surface 4.9.1965-00 GMT
500 mb
Fig 10 Surface 4.9.1965-12 GMT
500 mb

Fig. 6 - Fig. 10 - Surface and 500 mb analysis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D+1
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E
E
06
18

Fig. 11 31st Aug.
Stat.nary perturbations *a, b & e;*
Isochr. of perturbations *f & g.*

Fig. 12 31st Aug.
Stat.nary pert.tion *c*
Isochr. of pert.tion *h*

Fig. 13. 1st Sep.
Stat.nary pert.tion *d*
Isochr. of pert.tion *i*

Fig. 14 1st Sep.
Isochr. of pert.tion *A-1*

Fig. 15 1st Sep.
Isochr. of pert.tion *A*

Fig. 16 1st Sep.
Isochr. of pert.tions *A, A_c & B_c*

Fig. 17 1st Sep.
isochr. of pert.tion *B-1*

Fig. 18 1st-2nd Sep
isochr. of pert.tions *B, B*, B+1, B_1^* & B_2^**

Fig. 19 2nd-3rd Sep.
isochr. of pert.tion *C*

Fig. 20 2nd-3rd Sep.
isochr. of pert.tions *D-1 & D*

Fig. 21 3rd Sep.
isochr. of pert.tion *D+1*

Fig. 22 3rd-4th Sep.
isochr. of pert.tion *E*

Fig. 11 - Fig. 22 - *Isochrones of perturbations*

with a speed of nearly 100 km/h, ends dissipating over Puglie on the 4th September by 06 hours, having concerned the Tyrrhenian, Sicilia, and the centro-southern regions.

The precipitation associated with this segment, almost always characterized by thick cumulus, stratocumulus and cumulonimbus cloudiness, can be grouped into three centres of maximum intensity.

One of these affects western and northern Sicilia, the southern Tyrrhenian, and the Tyrrhenian versant in the Calabria area (maximum figures from 15 to 31 mm); the second centre concerns the Pescara area (16 mm); the third one affects the Gargano area (maximum figure 10 mm). The area most concerned by rains has been the westernmost part of Sicilia, with the value of 31 mm. Responsible for these rain maxima are, almost always, the thunderstorms.

Over southern Sardegna however cloudiness is scarce; the rains are light and intermittent and mingle with those of the preceding perturbation D; perturbation E can be distinguished by presence of an associated mesohigh.

10.2 Analysis of data show that perturbation E is essentially constituted of an upper cold front, at least during the phases concerning Sicilia; and that the temperature decreases recorded at surface are to be ascribed, for a great part, to the descending cold streams characteristic of thunderstorms.

In the final stage, when the perturbation went so far as to concern Puglie, the system seems to have reached a thermodynamic stability with cold air in the layers near surface and warm air at upper level, and this justifies its dissipation.

10.3 Element of remarkable interest in this perturbation is the presence over Sicilia of a ridge with axis from SE to NW, moving eastwards with a speed of about 100 km/h. It is a matter of one of those thunderstorm-highs often associated with squall lines, not detectable by ordinary synoptic methods but only through the mesoanalysis. On the barograms of the Sicilia stations the passage of the mesohigh is revealed by a pressure pick, or «nose», that shows up lower and wider over western Sicilia, where it is contemporary with rain. Over eastern Sicilia it is less wide and sharp and precedes rain by one hour about, whilst over southern Sicilia passage of the well-pronounced pressure wave does not give any rain. What has been observed seems therefore to be in agreement with the squall line theory, according to which the pressure wave generated by thunderstorm precipitation and associated strong downstreams has an independent development and, moreover, has a duration greater than that of the originating phenomenon itself.

11. THE PRECIPITATION FIELD FROM EXAMINATION OF DATA SUPPLIED BY THE ITALIAN MINISTRY OF WORKS HYDROGRAPHIC SERVICE

11.1 For a comparison and a finishing of the precipitation field analysis, apart from the «hourly» examination of data from the 150 stations of the *Servizio Meteorologico A.M.* network, examination has been carried out of «daily» data from about 3000 stations of the hydrographic network of the *Ministero dei Lavori Pubblici*. In this way, even if the possibility has been given up, for reasons of work amount, of a minute examination of the course of phenomena with respect to time, a very noticeable contribution has nevertheless been gained for what concerns overall distribution of phenomena in the space. Notwithstanding the interest that, from this point of view, the five charts of the daily isohyets from 1st to 5th September would show, one chart (Fig. 23) relating to precipitation total amount in the whole period from 08 GMT on August 31st to 08 GMT on September 4th can only be reported.

It seems important to underline soon a fact, well known to the hydrologists, that however should be well kept in mind also by the operative weather forecaster, fact due not to the complexity of the meteorological phenomenon "rain" in itself, but, in the case of Italy, also to the capricious nature of orography, nay, more generally.

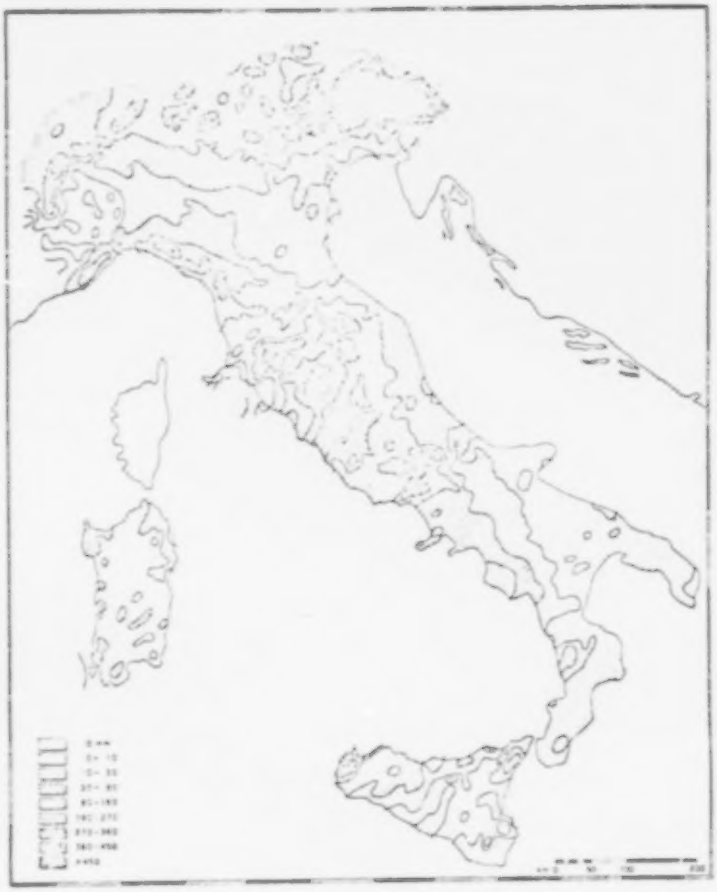

Fig. 23 - *Total precipitation amounts from 31st August 08 GMT to 4th September 08 GMT 1965*

of its geography. The fact consists in the great difference, appearing even from a superficial examination, of the course of the isohyets drawn through differing numbers of stations. In particular great differences have been remarked between daily isohyets obtained with data from the only 150 stations of the *Servizio Meteorologico A.M.* network and those obtained with the 3 000 data of the hydrographic network of the *Ministero dei Lavori Pubblici*. Such are the differences that the possibility must be excluded of carrying out a data extrapolation of the actual pluviometric stations of the former Service — otherwise useful enough for the study of a local situation -- for an estimate of a regional-scale precipitation. The comparisons and the tests carried out seem to show that for such a regional extrapolation it would be necessary to quadruplicate at least the number of the pluviometric stations, that is to increase the actual 150 ones to about 600, and these 600 stations should obviously carry out four daily observations, as the actual 150 already do.

11.2 Going back to the analysis allowed by use of the 3 000 stations of the second network, the daily charts strongly point out — as it results, on the other hand, also from the chart relating to the whole 4-day period — the showy effects due to orography: the largest rain amounts are in fact verified in the wind side of the prevailing southern and southwestern streams.

The largest rain amount is verified in the second day (from 08 GMT on the 1st to 08 GMT on the 2nd of September): it is the precipitation associated with passage of front indicated by B, the front directly connected with the upper cold air outbreak of recent origin, reaching Italy from a general direction varying from N to NW.

In relation to the orographic effects the daily rain amounts have been examined also statistically in regard to altitude. All the stations have been subdivided into groups according to elevation: for each altitude interval the percentages have been determined of those stations which have recorded generical precipitation or precipitation belonging to determined amount steps, day by day, region by region, and by groups of basins.

The overall examination of this situation development has shown a general increase in the total amount of precipitation outside the layer 150-300 m, because it

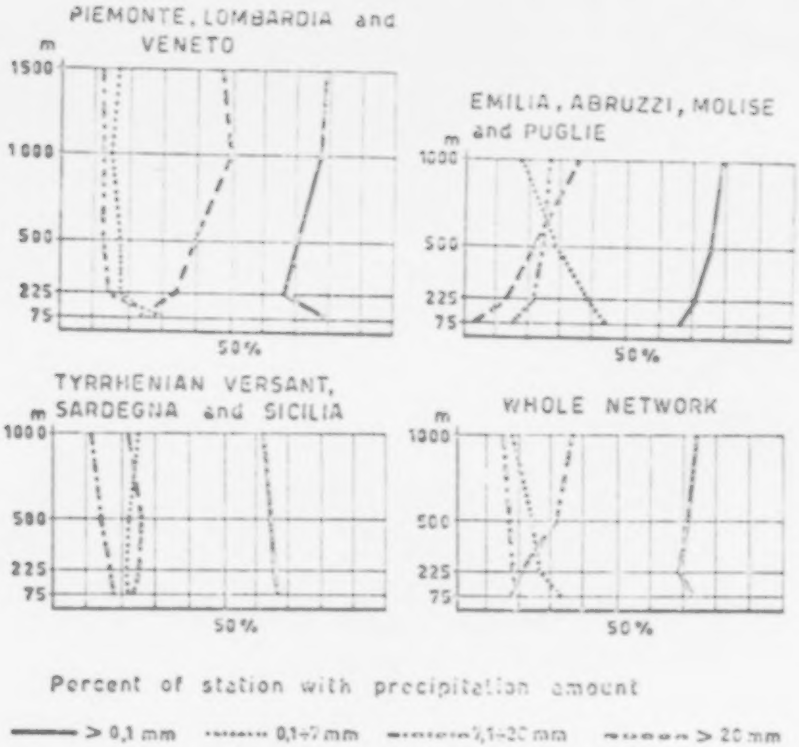

Fig. 24. - Percent of stations which have recorded rain

has resulted that percentage of stations which have recorded rain increases either going toward lower altitudes (up to 71% at sea level) either going toward higher altitudes up to as much as 74% for all the stations elevated higher than 750 m (1). In the single days and single regions changes with altitude in this percentage are verified to have occurred also in moods very different one from the other (Fig. 24).

11.3 The following table reports the rain amounts, recorded day by day, during the whole period considered, at 13 pluviometric stations, selected according to a geographical criterion among those which have recorded higher values.

RAINFALL (mm) FROM 09 GMT ON THE DAY BEFORE TO 09 GMT ON

SITE	ELEVATION (metres)	SECTION	Sept. 1, '65	Sept. 2, '65	Sept. 3, '65	Sept. 4, '65	Sept. 5, '65	Total Amount
Barcis	400	Venezia	19,6	500,0	328,8	2,4	—	850,0
Diga Cellino . .	350	Venezia	21,5	500,0	220,5	3,0	—	745,0
Villa Santina . .	363	Venezia	13,8	347,3	189,7	11,5	1,1	563,4
Baccano . . .	225	Roma	5,7	347,4	141,2	10,0	—	504,3
Forno	892	Milano	261,0	17,4	22,0	5,5	—	458,5
Bolsena . . .	348	Roma	229,6	80,0	73,6	1,0	0,2	384,4
Pescasseroli . .	1150	Pescara	—	272,0	22,8	60,4	0,2	355,4
Lentina (Contrada) .	125	Palermo	23,4	297,0	—	13,2	—	333,6
Favale di Malvaro .	380	Genova	216,2	47,5	30,2	15,1	0,2	309,2
Roccalbenga . .	525	Pisa	198,0	85,0	13,7	—	—	296,7
Palagnana . . .	710	Pisa	123,0	139,0	24,0	6,0	2,0	294,0
Itri	165	Napoli	13,0	231,0	25,0	19,6	—	288,6
Pianello . . .	384	Bologna	88,0	97,8	41,6	3,0	0,2	230,6

Notice: In the above table the commas are to be considered as being points.

12. BEHAVIOUR OF THE ATMOSPHERICS (Fig. 25)

It is known from experience that with a strong thunderstorm activity are associated remarkable concentration and extension of atmospherics, which often give an immediate idea on intensity of the phenomenon in progress.

For situation occurred on early days of September 1965 it can be said that an idea on actual importance and extension of phenomenon can be much better acquired from examination of the electromagnetic discharges than by examining the relating weather reports only. On the 31st August the thunderstorm activity is intense over Toscana

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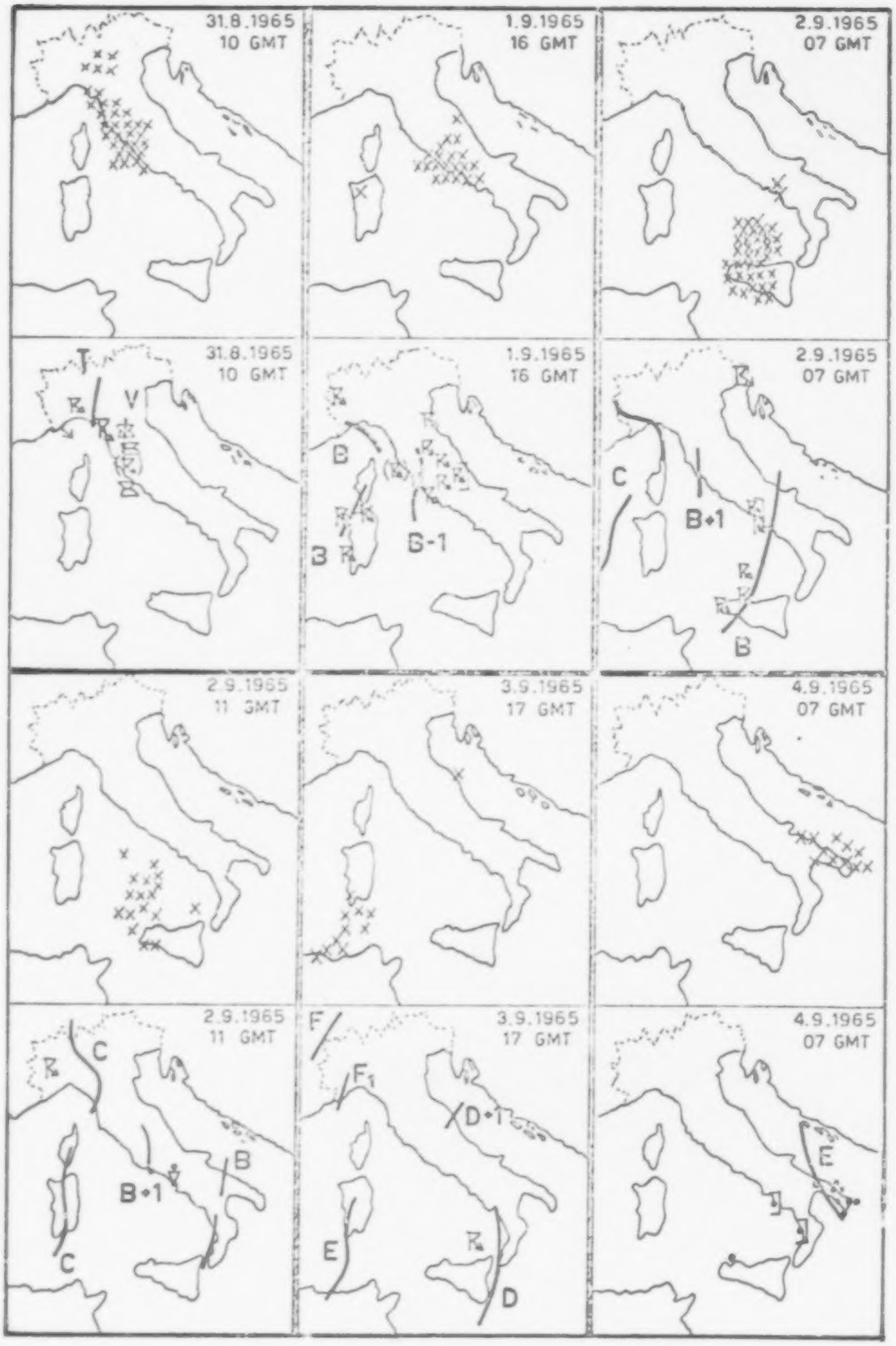
(1) Inside the above layer percentage of stations which have recorded rain is 68%.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2.9.1965
07 GMT
C
B+1
B
2.9.1965
11 GMT
3.9.1965
17 GMT
4.9.1965
07 GMT
2.9.1965
11 GMT
C
B+1
B
C
3.9.1965
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E
D
4.9.1965
07 GMT
E

Fig. 25 - Six comparisons among recorded electromagnetic discharges, contemporary weather reports and perturbations

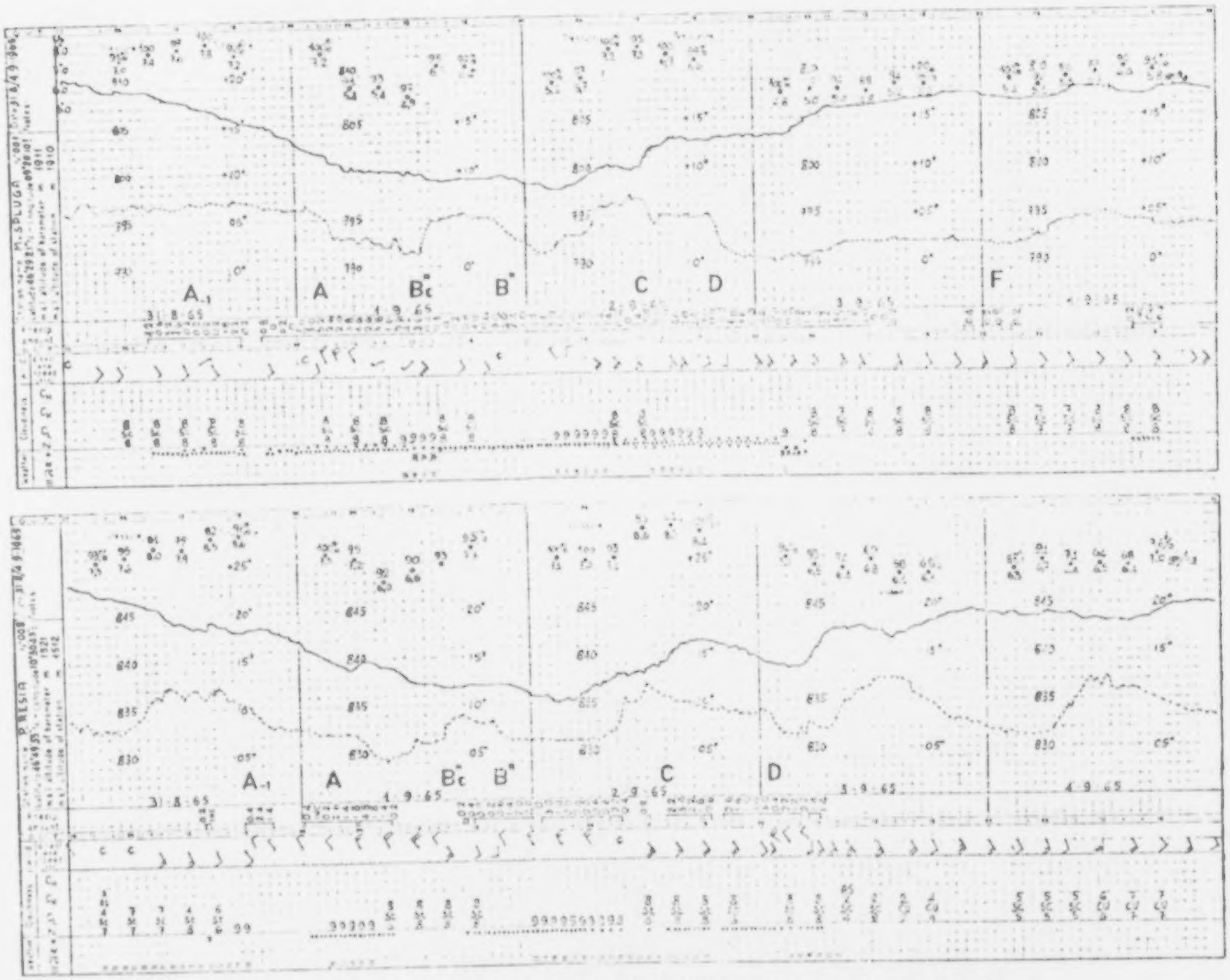

Fig. 26 - Passo Resia and Monte Spluga - individual station time cross section cards.

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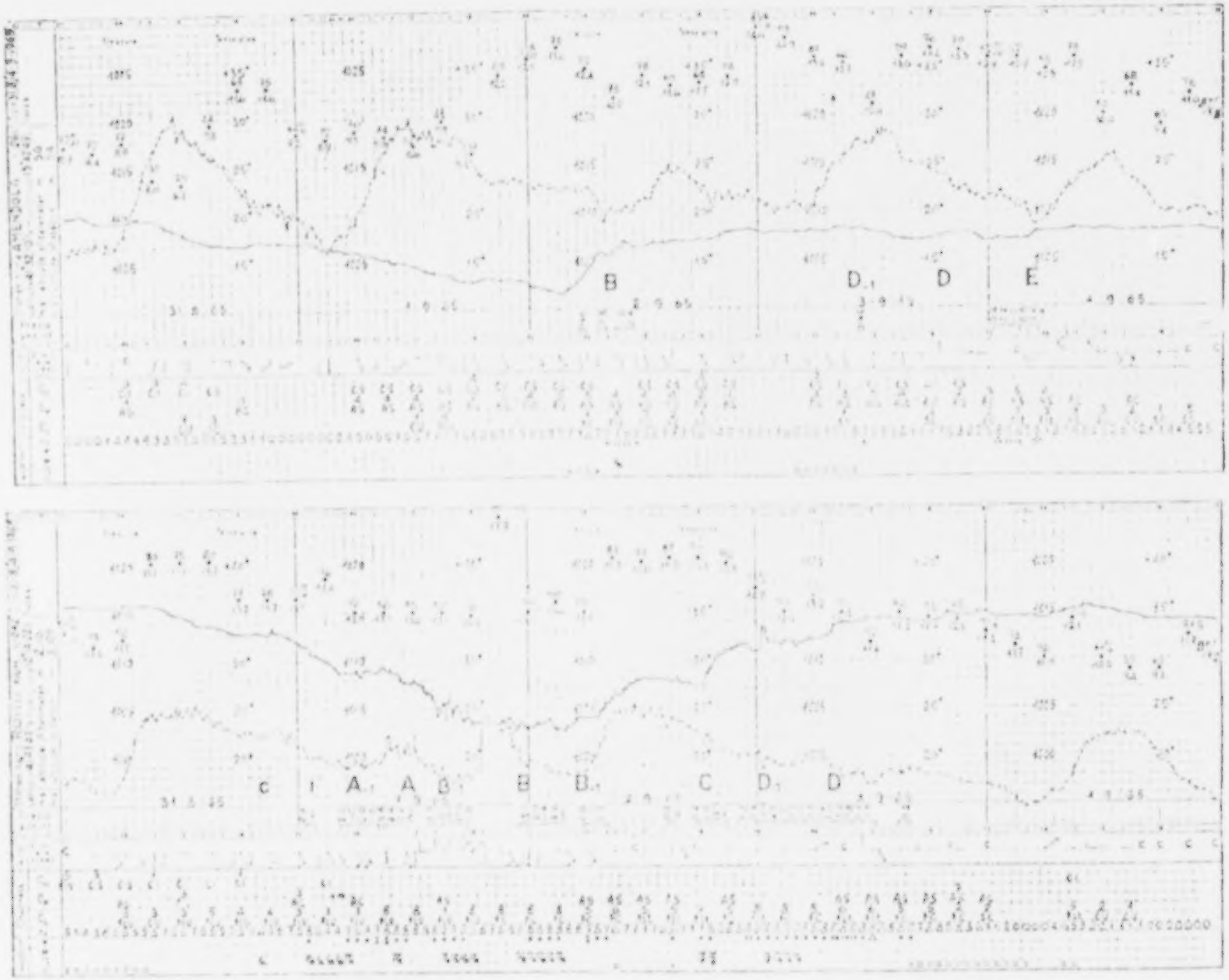

Fig. 27 - Roma-Fiumicino and Foggia-Amendola - Individual station time cross section cards.

and the atmospherics concentration is really exceptional over that area. The same is verified over Lazio, Campania and a part of Umbria on the 1st of September. The good agreement must be pointed out between distribution of atmospherics and frontologic observation: two perturbations, B-1 and A+1, concern in fact the mentioned regions.

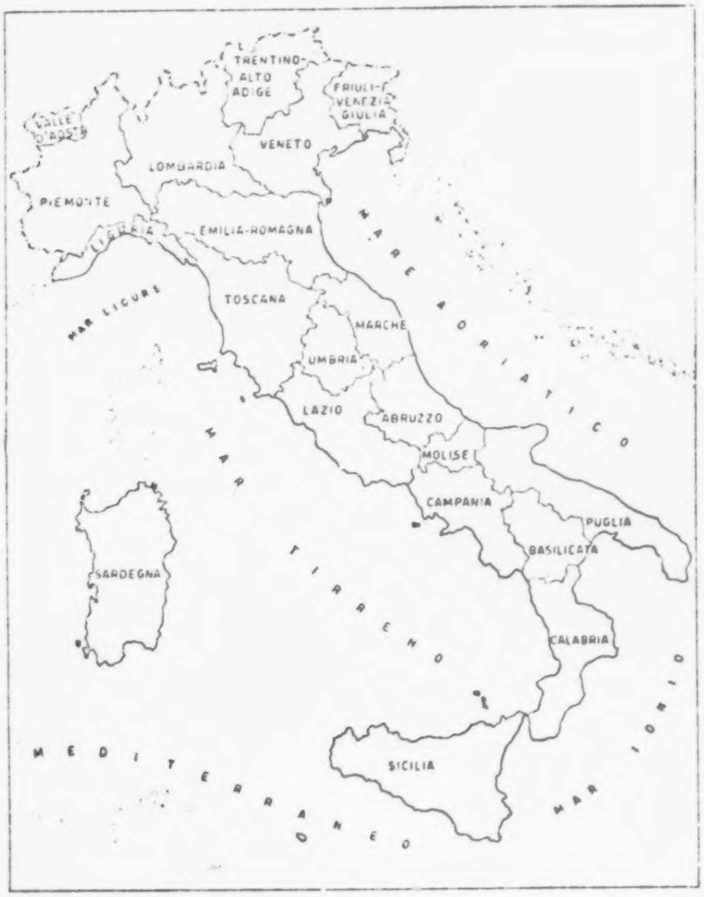
TRENTINO-ALTO ADIGE
FRIULI-VENEZIA GIULIA
VALLE D'AOSTA
VENETO
LOMBARDIA
PIEMONTE
LIGURIA
EMILIA-ROMAGNA
MARE ADRIATICO
MAR LIGURE
TOSCANA
MARCHE
UMBRIA
LAZIO
ABRUZZO
MOLISE
MAR TIRRENO
CAMPANIA
PUGLIA
BASILICATA
SARDEGNA
CALABRIA
MAR IONIO
SICILIA
MEDITERRANEO

Fig. 28 - *Map of the Italian regions*

The 2nd of September is characterized by violent and numerous thunderstorms over eastern Sicilia. In this case, too, the extension of the atmospherics is impressive.

Over the sea, atmospherics constitute the only meteorological information available, and noteworthy is also the fact that the concentration of discharges observed on the Canale di Sardegna on 3rd of September at 17 GMT is the only element which allows to localize, in this area and at this time, a perturbation (front E) which will impact Sicilia by 22 GMT.

The weather improvement verified on the 4th is concomitant with a rarefying and then a disappearing of the electromagnetic discharges. Although the prognostic value of atmospherics is poor, as these appear simultaneously with thunderstorms, however they constitute a precious help for the synoptic meteorologist, since, as it has been seen, they allow detect perturbations in stationless areas (for example, the sea) and therefore they make up, in a sense, for limited meteorological information due to scarcity of stations. Moreover, when the atmospherics distribution shows an exceptional character, it can be said that something exceptional is occurring.

It can be remarked, as an example, that the thunderstorms verified at Trapani, Palermo, Ustica, Prizzi on 2nd September at 08 GMT such as they appear in the synoptic weather reports, do not suggest any idea of exceptional phenomena, whilst examination of atmospherics data immediately do. As it may be recalled, that morning the thunderstorm phenomena took on dramatic proportions, and casualties, damages to crop and houses were complained.

13. CONCLUSION

Persistence of weather and intensity of associated rains can be deemed as due to the following factors:

a) Path and speed of motion of the upper cold depression over England on the 31st August. In fact this depression follows an almost meridian trajectory and is fast (about 1 800 km in 24 hours). Such evolvement is less frequent as depressions usually move west to east with a speed of the order al 500 km. in 24 hours.

b) Consequent persistence, over Italy, of a mean flow of southern streams which convey warm and moist air, into which, at medium levels, marked pulses of cold air introduce themselves. Important is the effect of the sea, that humidifies the air masses and rapidly transforms the cold air of the low layers.

c) Strong thermal contrast between the Mediterranean warm air and the polar cold air. Such contrast has been favoured by fast southerly motion of the cold air that has not had the possibility of modifying itself before reaching the Mediterranean.

d) Strong vertical instability conditions as a consequence of upper afflux of cold air masses of recent origin.

e) Orographic effect.

The detailed analysis has pointed out:

1) Complexity of the single perturbations, in particular the presence of instability lines preceding the cold front, and of post-frontal secondary perturbations, almost always present, at times more intense than the front itself.

2) Valid help provided by the atmospherics in localizing position of a perturbation, or in estimating its intensity.

3) Necessity, for a good analysis and hence a good prognosis of the precipitation field, of a network of pluviometric stations, carrying out several daily observations, much denser than the actual 150-station network of the *Servizio Meteorologico A.M.*

14. ACKNOWLEDGEMENTS

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We also thank the *Servizio Idrografico* of the *Ministero dei Lavori Pubblici* for the meteorological documentation kindly supplied.

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PRIMI RISULTATI DI UNA INDAGINE SULLA DISTRIBUZIONE DELLE PRECIPITAZIONI IN ITALIA IN RELAZIONE ALLA SITUAZIONE METEOROLOGICA

by Adriano Gazzola (Italy)

(The full text of the report is available in Italian only and was published as Supplemento al No. 4, 1969, Anno XXIX, Rivisti di Meteorologia Aeronautica. It can be obtained from:

Consiglio Nazionale Della Ricerche,
Instituto di Fisica dell'Atmosfera,
Piazzale Luigi Sturzo, 31
00144 - ROMA - EUR.)

SUMMARY

The synoptic-climatological criteria on the basis of which a research is carried out having the purpose of going deep into the knowledge on the detailed sitribution of precipitation in Italy in connection with the weather situations and on the characteristics of the evolution, at short term, of the same situations, are described.

The results of a classification in types of the topographic configurations at 1,000 and 500 mb. at 00 GMT in decennium December 1955 - November 1965 are exposed and discussed. The classification refers particularly to Italy and neighbouring regions of the Mediterranean.

Each "type of situation" is characterized by a "surface-altitude coupling", which has its own individuality; the situations classified in the same types, at 1,000 mb. and 500 mb. separately, belong to the same coupling.

For each coupling mean topographies of ten situations at 1,000 and 500 mb. are traced: mean thermic configurations are obtained as 1,000 - 500 mb. relative topographies. Corresponding mean precipitation maps for 24 hours are elaborated using data of about 450 pluviometric stations of the Servizio Idrografico del Ministero dei Lavori Pubblici. For each coupling similar mean maps are also traced for the situations of the corresponding next days.

As an example, elaborated mean maps for ten couplings are reproduced and briefly explained.

The results obtained by the present research will be considered as a basis for further study on the peculiar characteristics of the alluvial situations in Italy.

CCMS No. 2

PROPOSAL FOR A PRACTICAL SYSTEM OF ITALIAN SATELLITES FOR THE MEDITERRANEAN METEOROLOGY

by B. Bizzarri, M. Colacino, G. Fea and M. Giorgi
(Italy)

(This text, published in March 1970, is available in Italian only. It can be obtained from:

Consiglio Nazionale Della Ricerche,
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CCMS No. 2

DESIGN OF A NATIONAL CENTER FOR COLLECTION AND ELABORATION OF SATELLITE DATA

Summary by B. Bizzarri, G. Fea, M. Giorgi, S. Palmieri (Italy)

A National Center for the acquisition and processing of the data from satellites has been proposed, with three main purposes:

1. providing the Country with suitable tools for participation to the international programmes of earth survey;
2. collecting all the data provided by several Italian planned satellites;
3. performing the interdisciplinary co-operation among the several national environmental services.

Economical benefits are pointed out, especially as regards meteorology, hydrology and agriculture assistance, and earth resources research and planning.

The following activities have been envisaged and described (with respect to meteorological applications):

1. satellites tracking and data acquisition;
2. ephemerides computation and antennas control;
3. data digitizing;
4. images rectification;
5. automatic stations interrogation;
6. images display;
7. satellite data archiving;
8. pre-process for numerical application and archiving;
9. automatic collection of ordinary meteorological data and diffusion of meteorological information;
10. utilisation of numerical models for the operational meteorological service;
11. ordinary meteorological data archiving;
12. study teams;

13. scientific calculus;

14. library.

Activities nn. 9, 10 and 11 are already in use (at least partially) at the Italian Meteorological Service, which could as well support in part activity no. 5. Activity no. 8 is an interface peculiar of each environmental service which could require an on-line numerical application.

Afterwards, an example of system which could possibly support most common activities has been drawn out. The system mainly consists of:

1. two IBM 1800 process computers for real-time activities nos. 2, 3 and 5;
2. two IBM 360/65 scientific computers for activities nos. 4, 7, 8 and 13;
3. display facilities for activities nos. 6 and 7.

(Activities nos. 9, 10 and 11 are performed at the Italian Meteorological Service by the IBM 360/30, 360/40 and 360/25 systems respectively).

The cost of the system has been estimated at about 8 million dollars, or .27 million dollars plus .17 million dollars per month. The cost of buildings and soil depends on the number of environmental services taking part in the activities of the Center. The number and type of antennas depends as well on the amount of satellites which will be available after 1972-73.

"PREMETEO" Project

NRC PROJECT FOR THE DEVELOPMENT OF METEOROLOGY IN ITALY

"Programme for the development of the national meteorological services for meteorological assistance to the civil defence of the Italian territory and for research and study development on dynamic climatology and meteorology of the Mediterranean region".

by M. Giorgi and G. Pea (Italy)

The exceptional meteorological events that with inevitable occurrence continue to cause enormous damages to the Italian territory, to civilian, industrial and agricultural resources and losses of human lives, continuously re-propose the necessity of adopting suitable protection means in order to minimise the disastrous effects they produce.

As an example, about 300 billion of lire is the price that Italian agriculture has to pay for damages caused by floods, down-pours, hail-storms and exceptional atmospheric phenomena in general.

The mean annual loss produced by the destructive effects of hail to valuable cultures is about 100 billion of lire.

Clearly, on the basis of the present capabilities, it is not possible to eliminate or reduce the violence of the natural forces involved, but it is obvious that such damages could be partially attenuated or avoided by means of an effective meteorological organization which could be able to forewarn in due time, the civil defence bodies and the people of the areas interested of the possible approaching of particularly dangerous atmospheric disturbances.

Since November 1966, after the flood of Florence, Tuscany and other areas of the Venetian region, Prof. V. Caglioti, President of the NRC of Italy, proposed to the Presidency of Ministers, a first project prepared by the Istituto di Fisica dell'Atmosfera (IFA) Rome, whose aims were the following:

1. to facilitate at a maximum and to speed up by means of prompt financial interventions the acquisition and the setting up of the equipments and to develop new methods and meteorological observational systems, already known and mentioned, or under study and expected for a period of time regarded as too long;

2. to promote the activity of a rapid and effective information centre for meteorological data, essential to Bodies, Technical Services and prompt intervention Services (Civil Defence);

3. to promote adequate actions of national and international nature in order to intensify the present meteorological and hydrologic networks, relative to the requirements of the national territory and the Mediterranean region;

4. to intensify the initiatives already taken for the carrying out of an international study and research centre on dynamic climatology and meteorology of the Medterranean region.

The National Research Council - on the basis of the actual needs recently reappeared after the other disastrous events - in December 1968, has taken again the action to predispose an organic Programme for national meteorology (Project "PREMETEO") devoted to the development of the national meteorological services, for meteorological assistance to the civil defence of the Italian territory and for the study and research development of meteorology and climatology of the Mediterranean region.

On this purpose, the NRC has promoted various meetings between the chiefs of the national services for meteorology and the Istituto di Fisica dell'Atmosfera (IFA).

IFA is one of the main research bodies of the NRC and was established to promote, intensify and co-ordinate the research activity of Meteorology and Atmospheric Physics in Italy in support and in collaboration with the interested national Services:

- The Air Force Meteorological Service;
- The Hydrographic Service of the Ministry of Works;
- The Central Office of Meteorology and Agriculture Ecology of the Ministry of Agriculture and Forestry;
- The Hydrographic Institute of the Italian Navy.

Moreover, the Institute carries out a didactic activity for the training of scientific and technical personnel specialized at all levels.

The scientific activity of the Institute covers different sectors of meteorology and atmospheric physics with particular regard to the problems concerning the Mediterranean region. This manifold activity is carried out through the work of different specific sections, headed not only by researchers of the Institute, but also by highly qualified personnel of the Air Force Meteorological Service and of other Services on the basis of suitable conventions (with the Ministry of Defence and Ministry of Agriculture and Forestry).

The main research topics concern dynamic meteorology, climatology, solar radiation, microphysics of the hydrometeors, upper atmosphere, aeronomy and so on. The Institute carries out also some special programmes relative to the studies on hail phenomena, air radioactivity, cyclogenesis on the Mediterranean region and land-air or sea-air thermal exchange.

The experience so far acquired through the activity of IFA and its collaborators of the Meteorological Services, has induced the NRC President to draw up a development project for the Italian Meteorology.

To the drawing up of the Project "PREMETEO" have collaborated in good agreement and in accordance with the NRC instructions, the following chiefs of Institutes and Services:

- Prof. Maurizion GIORGI - Director of the Institute of Atmospheric Physics of the National Research Council;

- Gen. Giorgio FEA - Chief of the Italian Air Force Meteorological Service - Ministry of Defence;

- Ing. Tomaso GAZZOLO - Chief of the Hydrographic Service of the Ministry of Works;

- Dr. Ottavio SARRICA - responsible for the Central Office of Meteorology and Agriculture Ecology of the Ministry of Agriculture and Forestry.

The project covers two distinct programmes.

The first of these programmes concerns the development of the national Services, already mentioned, and has the twofold aim to up-to-date the organization and the equipments of the Services and to reach a more effective weather forecasting system which permits to signal, in due time, the meteorological event development of particular intensity, enabling thus the Civil Defence Services to act promptly for the protection of human lives and the welfare of the national community.

The second programme, since the formation of the meteorological disturbances and of weather conditions generally is connected to the meteorological situation of the Mediterranean, concerns an intense development of research and study activity including also the establishment of an international Centre for the Meteorology of the Mediterranean, whose task is to improve the knowledge on dynamic meteorology and climatology of the Mediterranean region.

This region deserves to be carefully investigated because it is a centre of particular cyclogenesis and the meso-scale weather systems that form in it, advance and develop very rapidly: for example, it is worthwhile to recall, that the event which caused the ruinous flood of Florence in November 1966, developed in less than six hours.

On the other hand, the weather behaviour over Italy is somewhat complicated by orographic factors and by the presence of warm seas.

The air masses in motion over a complex surface formed by seas, plains and mountainous reliefs, as the region in question, are subject to rapid and intense exchange of heat, humidity and momentum.

All this implies not only the carrying out of suitable mathematical models as far as the region is concerned but also the collection of sufficient observational data.

For the research activity of the above-mentioned centre, to which can offer their own collaboration workers from all countries and in particular those of the interested countries, it is expected an important didactic activity, because the Centre would plan under the grant of the World Meteorological Organization (WMO) - a body of the United Nations that co-ordinated the meteorological Services of 114 countries - the establishment of an international school devoted to the training of scientific personnel, specialized for all the coutries facing the Mediterranean, or interested in it with particular regard to the personnel from countries in developing stage of the Northern Africa and the Near East.

It is expected that in this school and in this centre could carry on their activity not only Italian workers or those directly interested in the above-mentioned problems, but also those whose works and scientific experience assure a positive contribution of specific capacity.

The theoretical teachings will be integrated by practical exercises, seminars and monographic courses taught by specialists and by Italian and foreign scientists and concerning topics in meteorology and atmospheric physics with particular reference to the problems of the Mediterranean region.

The establishment of this Centre will fill the gap that has had its negative influence for a long time: in fact it will permit a better understanding of the phenomena governing the development of meteorological situations of the Mediterranean region and of circum-Mediterranean countries. Moreover, it will serve to train the personnel required by the Mediterranean countries to develop or to make more efficient the hydro-meteorological services and it will also represent for the positive results that undoubtedly will be obtained, a good example of how co-operation and mutual work among different people can contribute to the progress of science at service of mankind and of human societies.

The programme proposed by Italy, has already received a large favourable consent by the World Meteorological Organization and the required financial measures are being examined by the Italian government bodies.

The programme suggests for a five-year period a financial expenditure of 25 million dollars of which about 22.5 million dollars devoted to the development of the National Meteorological Services and about 25 million dollars for study and research Programme on the dynamic meteorology and climatology of the Mediterranean.

HISTOIRE ET TYPES D'ALLUVIONS EN ITALIE POUR LA PERIODE 1951-1968

Résumé

La Délégation italienne, qui participe au Symposium "On Flood Hazard Reduction", ouvrira les travaux en faisant l'historique des différents types d'alluvions et inondations en Italie, pour permettre ainsi aux experts de développer la discussion.

En particulier, il est fait mention des phénomènes météorologiques exceptionnels auxquels l'Italie, par sa configuration orographique et géographique, est particulièrement exposée. La nature des susdits phénomènes est telle, que leur origine doit être individualisée et leur évolution attentivement suivie dans les pays d'Europe et dans ceux du bassin méditerranéen.

Les alluvions, considérées parmi les plus graves calamités naturelles, qui se sont produites en Italie dans la période 1951-1968, sont rappelées succinctement.

Pendant la susdite période, les alluvions ont affecté :

- en 1951. En mars, les régions centrales et septentrionales de la Calabre et la Lucania occidentale. En octobre, la Calabre méridionale, la Sicile orientale et la Sardaigne sud-orientale. En novembre, la Ligurie, le Piémont, la Lombardie, la Vénétie et l'Emilie-Romagne.
- en 1953. En octobre la Calabre méridionale, au sud de la ligne tirée entre les Golfes de St Euphémie et de Squillace.
- en 1954. En octobre, certaines zones de la côte Salernitaine et Amalfitaine.
- en 1956. En avril, l'Emilie méridionale.
- en 1957. En juin, une zone du Piémont et du Delta du Pô.
- en 1963. En octobre, le Vajont.
- en 1965. En septembre, les régions de la Vénétie, l'Ombrie, la Toscane, le Latium et la Sicile.
- en 1966. En octobre, la Ligurie orientale, le Piémont, la Campanie et, en novembre, la Toscane, les régions de la Vénétie, l'Emilie-Romagne, la Lombardie.
- en 1968. En octobre-novembre, la Ligurie et le Piémont. En décembre, la Campanie.

De chacun de ces événements est donné un cadre panoramique, comportant également des renseignements plus détaillés sur la délimitation du territoire touché, l'étendue et la durée des précipitations, la situation des trajectoires et des débordements des cours d'eau ainsi que sur les données hydrométriques.

Des indications de base sont données sur la typologie et sur les caractéristiques des alluvions ; l'on fait une distinction entre les bassins de portée ample et limitée, et l'on souligne les éléments qui caractérisent les crues et les précipitations qui se produisent dans les deux différents types de bassin. L'on indique l'influence des raz-de-marée sur les cours d'eau exondés et le phénomène de "l'acqua alta" (hausse du niveau de l'eau) dans l'Adriatique septentrionale.

Des renseignements généraux sur les interventions de l'Etat - dans le domaine des alluvions - sont fournis :

- intervention préventive, qui se concrétise par la construction d'ouvrages de défense hydraulique et par l'aménagement des zones montagneuses et vallonnées des bassins, ainsi que par des systèmes de contrôle des cours d'eau, des services de garde aux fabriques hydrauliques et par la programmation des mesures d'urgence ;
- intervention d'urgence pour secourir les populations sinistrées et pour limiter les dégâts et leurs conséquences ;
- intervention pour rétablir les populations affectées par une alluvion dans les conditions existantes avant l'alluvion même (reconstruction des biens publics et contributions aux privés).

Les organismes, grâce auxquels l'Etat effectue les trois types d'intervention, sont mentionnés.

Des renseignements sont donnés sur les limites d'application des diverses méthodes de prévision (météorologique, pluviométrique et hydrométrique) et sur l'implantation, en voie expérimentale, de systèmes modernes de relevé et transmission des données hydrométriques pour quelques cours d'eau.

La nécessité de localiser préalablement les zones plus facilement submersibles et les cours d'eau qui débordent fréquemment est soulignée. Cette localisation est indispensable afin de pouvoir prendre les dispositions les plus adéquates pour réduire, dans chacune des zones, les risques d'alluvions.

On a dûment tenu compte de l'exigence d'extraire autant que possible de l'ensemble des faits des indications utiles pour un ultérieur approfondissement des études visant à la limitation des risques et des dégâts dans l'hypothèse d'éventuelles futures alluvions.

Ce rapport comprend les paragraphes suivants :

- Descriptions générales des alluvions de 1951, 1953, 1954, 1956, 1957, 1963, 1965, 1966, 1968.
- Situations des territoires touchés par les alluvions ; données pluviométriques et hydrométriques.
- Typologie et caractères des alluvions.
- Interventions de l'Etat en matière d'alluvions.
- Thèmes d'étude pour la limitation des risques : prévisions des crues - repérages des zones alluvionnaires.
- Considérations finales.

CCMS No. 2

METHODS FOR THE PREDICTION OF STORM SURGES

by R. FRASSETTO (Italy)

Summary

Storm surges are responsible for the floods from the sea in coastal cities and areas of small altitude above sea level. Their prediction can be made with the use of models and data from sea levels, and atmospheric conditions in real time.

On the basis of past experiences three kinds of models are being considered for the case of Venice:

a) empirical - statistical models;

b) models based on the numerical solution of the idrodinamic equations;

c) analytical models.

On the long range studies, because coast lines are subsiding, coastal modifications which would endanger man properties must be studied.

Numerical models of ocean circulation, eustatism, land subsidence and the trend of meteorological modification due to man action must be considered.

The paper makes a brief review of the problems.

PHENOMENOLOGY OF FLOODS IN VENICE AS PRODUCED BY STORM SURGES OVER THE ADRIATIC

by A. TOMASIN (Italy)

Summary

The storm surges over the Adriatic are described.

Simplified preliminary models consider as an input only the most important factor. They are sea level and wind stress.

The effects are being studied from different points of view:

a) from the intensity fetch and duration of the wind over the Adriatic;

b) from the interaction of Adriatic and Ionian Sea;

c) from the phases and the combination of the representative forces.

The description is given of a preliminary model as applied to the case of Venice.

PROPAGATION OF FLOOD WAVE IN RIVERS WITH SPECIFIC REFERENCE TO THE ARNO RIVER

by F. GRECO (Italy)

Summary

A description is given of the methodology used in determining the Hydraulic characteristics of open channels, and of the necessary data, appropriate methods of analysis, and obtainable results.

In particular, the results obtained for a single reach of the Arno River are described.

Finally, it is explained, on the basis of these results, how the problem of the flood waves propagation has been faced.

(More data may be obtained from Mr. F. Greco, Pisa University, Italy).

SICUREZZA SOCIALE E PROTEZIONE CIVILE - L'AZIONE E GLI INDIRIZZI DEGLI ORGANI CENTRALI E PERIFERICI DEL MINISTERO DELL'INTERNO - INTERVENTI E DIRETTIVE DI IMPIEGO - SVILUPPI LEGISLATIVI

and

LA PROTEZIONE CIVILE IN ITALIA

(These are the titles of two booklets distributed in the course of the meeting. They describe the different levels of the centralized organization set up in Italy for the protection of the population in case of emergency. They are intended for educational use and have been published in Italian only. Copies may be obtained from:

Ministero dell'Interno,
Direzione Generale della Protezione Civile,
Roma.)

EXPOSE DE M. LE PROFESSEUR VITANTONIO PIZZIGALLO, DIRECTEUR GENERAL, SUR LES MESURES PERMANENTES DESTINEES A AMOINDRIR LES DANGERS D'INONDATIONS RECURRENTES SE RAPPORTANT, TOUT PARTICULIEREMENT, A L'ACTIVITE DE PREVENTION CONFIEE A L'ADMINISTRATION DES FORETS DANS LE SECTEUR DE LA PROTECTION ET DE LA CONSERVATION DU SOL

Monsieur le Président, Messieurs,

"Les défis à la société moderne" auxquels le Comité constitué au sein de l'OTAN s'efforce de faire face aujourd'hui, dérivent en grande partie de l'action de l'homme sur son propre environnement.

En me référant à l'Italie je désirerais donc traiter de l'activité de prévention confiée à l'Administration des Forêts pour une protection organisée du sol dans les zones de montagnes ou de collines, dans lesquelles ladite activité assume, justement, une importance primordiale par suite des effets du déboisement qui s'est produit et des inondations qui se sont succédées avec une intensité croissante en ces dernières décennies.

En examinant sommairement la disposition du territoire italien, l'on s'aperçoit de suite que les 4/5 de notre pays (78% exactement) sont constitués par des montagnes et des collines, avec des terrains fortement escarpés appartenant pour la majeure partie aux ères tertiaire et quaternaire, ce qui fait que nous sommes là en présence de roches facilement décomposables, là où les eaux qu'il a été convenu de dénommer "violentes" ou "sauvages" ont une puissance d'érosion considérable.

Par contre, une simple recherche rétrospective portant sur la couverture forestière nous met à même de constater qu'en Italie, à la fin du XVème siècle, sur 30 millions d'hectares de superficie territoriale, la moitié environ, soit 15 millions d'hectares, étaient recouverts de forêts luxuriantes, mais en l'espace de quelques siècles à peine, à la suite de déboisements considérables, l'on est passé aux 6 millions environ d'hectares actuels, ce qui fait seulement du 21% de la superficie du territoire.

Ceci exposé, il est aisé d'imaginer ce qu'a signifié pour notre pays la réduction - en l'espace d'un nombre de siècles restreint - de la surface des forêts, tant au point de vue de la quantité que de la qualité, exception faite, naturellement, des quelques forêts gérées par l'Administration des Forêts domaniales de l'Etat, qui, à vrai dire, ont été remarquablement conservées.

Tout ceci ne suffit pas. Il y a lieu d'ajouter, en effet, qu'il s'est produit, dans le dernier après-guerre, un dépeuplement considérable de la montagne, ce qui fait qu'à la suite de cet exode vertigineux de la population rurale qui a abandonné les champs, une importante fonction de l'homme a fait défaut, à savoir les travaux d'entretien des rigoles d'écoulement et de tous les autres aménagements destinés à assurer le régime approprié des eaux en montagne.

En tout état de cause, la conséquence d'une extrême gravité est le défaut partiel voire total de protection de la forêt et partant - en considérant les conséquences désastreuses qui en ont découlé - nous sommes hélas contraints actuellement à payer les intérêts passifs d'un capital détruit depuis longtemps.

Après ces brefs préliminaires, nous examinerons en une rapide synthèse quel pourrait être le programme futur à appliquer, sur le plan pratique, non seulement à ce qu'il serait opportun de faire à brève échéance mais aussi à plus long terme, étant donné que les interventions requises ne sauraient être exécutées en une seule année mais doivent - en respectant une continuité qui s'impose - être réalisées graduellement en des périodes de temps plus étendues, d'un ordre de grandeur de plusieurs décennies.

Il y a lieu de tenir compte, en effet, qu'à la suite du dépeuplement dont j'ai parlé il y a quelques instants, au moins 4 millions d'hectares, naguère exploités par l'agriculture, sont aujourd'hui abandonnés dans les montagnes et collines d'Italie.

Et bien, de ces 4 millions d'hectares, 3 millions au moins (soit ceux des terrains qui sont particulièrement escarpés et ceux ne permettant en aucune façon une culture agraire rentable) devraient être destinés au reboisement suivant un programme progressif différé dans le temps (une trentaine d'années au moins).

En même temps, l'on devrait adjoindre, à l'activité du reboisement, celle visant à l'aménagement et à la consolidation des très nombreux éboulements, car il existe en Italie des zones très vastes fortement ébouleuses nécessitant des interventions urgentes et prioritaires.

Il y a lieu de considérer tout aussi indispensables les interventions ayant un caractère d'entretien, à soutenir par des financements adéquats et continus, afin de garantir, dans le temps, la pleine efficacité et le bon fonctionnement des ouvrages réalisés.

Je suis donc d'avis qu'il se présente actuellement une condition favorable, justement parce que cette avidité d'avoir des terrains disponibles, déplorée lors des siècles derniers et qui a amené à un déboisement sans discrimination de vastes contrées pour y instaurer la culture agraire, n'existe plus aujourd'hui. La disponibilité de ces zones impose, par conséquent, la nécessité absolue d'intervenir par des travaux de reboisement parce que tout aménagement hydraulique quel qu'il soit réalisé dans les plaines - d'utilité indiscutable et pour autant qu'il soit rationnel et parfait - résisterait bien difficilement à la furie des eaux si nous ne songeons pas à aménager nos montagnes.

Le programme futur doit être, par conséquent, celui d'un vaste reboisement dans les zones montueuses et en haute colline, et tout spécialement dans les zones en mauvais état et en pente très raide ; un tel reboisement est une condition sine qua non, sans lequel aucune oeuvre de protection du sol pourrait être considérée comme étant organique.

Quoi qu'il en soit, dans le cadre de la protection du sol, je désirerais souligner de plus, ainsi qu'il appert clairement des conclusions auxquelles est récemment parvenue une Commission interministérielle ad hoc - qu'une telle protection ne saurait être conçue administrativement suivant la mosaïque de notre régionalisation. La protection du sol, en effet, doit avoir un caractère national et doit être conçue suivant les bassins hydrographiques.

A cet égard, il suffira de considérer le bassin du Pô - qui fait partie de six régions différentes ainsi que d'une part d'une septième - pour se rendre aisément compte que la protection du sol dépasse les limites des régions pour assumer un caractère et un intérêt national, et qu'elle doit être mise à exécution de façon organique et systématique dans le bassin hydrographique tout entier.

Ceci dit, j'estime utile d'ajouter une autre considération sur le problème important de l'allocation des fonds, étant donné qu'en ces vingt dernières années l'on n'a pu disposer que de financements irréguliers et très exigus qui ont permis de reboiser guère plus de 400 mille hectares, à une moyenne annuelle d'environ 20 mille hectares - chiffre bien modeste lorsque l'on considère malheureusement qu'en Italie, des incendies ont lieu sur une superficie d'une trentaine de mille hectares tous les ans, et que près d'un tiers en demeure entièrement détruit.

C'est d'ici que naît, par conséquent, pour mon pays, la nécessité indispensable qu'en vertu d'engagements précis de nature politique, l'on puisse trouver des résolutions favorables moyennant la promulgation de mesures législatives appropriées visant à assurer des financements adéquats non seulement et surtout pour la mise à exécution d'interventions d'aménagement dans le secteur de la protection et de la conservation du sol, mais également pour toutes les initiatives à prendre dans le domaine de la prévention d'incendies de forêts.

Avec votre permission, je voudrais conclure mon bref exposé en évoquant, à l'appui de ce que représente réellement l'importance de la forêt aux fins d'un régime satisfaisant des eaux, une pensée que j'ai eu l'occasion de lire il y a quelques années dans une publication américaine des plus à la page.

Il me semble, si je me souviens bien, que le titre de ladite publication était : "La politique de l'eau pour le peuple américain".

Et bien, au bas d'une photo représentant une source limpide jaillissant d'une forêt luxuriante, il était fait mention de la pensée suivante : "ce n'est qu'en une région où les eaux sont claires que l'on peut considérer comme permanentes l'agricultures et une saine structure de la société".

Messieurs, je vous remercie.

CCMS No. 2

INTERVENTIONS OF THE ITALIAN ARMED FORCES FOR THE ASSISTANCE OF POPULATIONS OF DISTRESS

The following statement has the aim of indicating the provisions made by the various national authorities to planning interventions of the Italian Armed Forces for the assistance to population in distress.

This planning has the aim of:

- affording the possibility of timely intervention over the entire national territory;
- ensuring the adherence of such intervention by granting decisional powers also to peripheral military authorities (military region, area and garrison commands);
- avoiding improvisation and overlapping of assistance actions.

It is further necessary to state that the assistance assured by the armed forces is to be considered as a support to that of the civilian authorities, both in the sector of management as in that of implementation.

This complementary action stems from the fact that the main tasks of the armed forces remain those of institutional defence, regardless of the situation created by any catastrophe.

If the part of the armed forces in aid of a distressed population can be defined as complementary with respect to the assistance developed by the various civilian administrations (services), this does not exclude the fact that the help given by the military bodies can be decisive for the success of such assistance.

And indeed, a situation might arise in which the armed forces have the possibility of ensuring certain given services both in view of their numbers and their technical equipment and capabilities.

Those special services can consist of air and sea transport resumption of communication facilities (bridges, viaducts, etc.) or telecommunication networks, the setting-up of field health units, the supply of large quantities of commodities, food, etc.

After this preliminary statement we shall briefly survey what has already been achieved both at executive and at operational level.

Guidance of assistance work:

- at the onset of a state of emergency an "interforce operational centre" enters into action at the Army Staff, this centre receives information and requests (from the Ministry of Interior or from the peripheral Commands of the armed forces) transmits operational orders pertaining to planned interventions. Let us, however, keep in mind that provisions are also made for inistives of peripheral commands. The Centre issues orders necessary to face all requirements which could arise suddenly; this operational centre in turn detaches its own staff to the civilian ministries interested in assistance operations;

- if the magnitude of the calamity striking a given territory requires a massive use of elements of the various armed forces, the need may appear of posting an ad hoc military command on the spot; this command will be named "Operational Assistance Centre". Provision is made that this operational centre will act under the orders of the command of the competent military region, in agreement with the "local co-ordination centre", and with staff supplied by this command, as a sector of the Ministry for Interior.

The operational organization of military assistance is implemented as follows:

- "public help units" supplied by the Carabinieri, as an integration to similar aid given by the Police Corps; they are in charge of first aid and are supplied with the special equipment for this work, control the situation, define distressed areas, etc.;

- "mixed mobile ready intervention columns" supplied by regional military commands; these units have the duty of performing non-specialized first-aid operations, necessary for the control of immediate requirements, particularly the saving of human lives;

- "mixed reinforcements units" which are a manoeuvre element in the framework of the regional command, with the duty of specialized help intervention, and of reinforcing the action of the "mixed mobile ready intervention columns";

- air transport for the transfer of the "central manoeuvre unit" of the fire brigades, this intervention can be implemented within the limited time of 2-3 hours.

In the framework of the assistance given by the armed forces to face possible emergency situations, it is deemed necessary to know what has been done and what is planned in case of need, in view of the fact that we are located in Venice, a city which is precious to all, for its cultural and artistic treasures.

The Air Force weather forecast service co-operates with the Researchers of the National Research Council in order to prepare short-term forecasts. The Air Force has declared its readiness to increase the co-operation of its staff and the use of aircraft. Agreements are underway to implement such co-operation.

The intervention of the Lagoon Units of the Army and of the Navy has been planned in view of the needs of assisting the population in case of the catastrophe, in view of the particular physical environment.

This is what has been done in Italy in order to co-ordinate the help of the armed forces in case of disaster. In this connection the Study Centre for Civil Defence and we, present here, are ready to give any clarification requested.

It would be of paramount interest for us to be informed on what has been provided by the armed forces of the other nations represented here to help populations to face emergencies following natural catastrophies.

FIGHTING FLOODS AND STORMSURGES IN THE NETHERLANDS

by Ir. P.J. Womelsfelder (Netherlands)

1. An urgent affair

In the Netherlands both inundations by severe stormtides in the low coastal areas as well as by extreme high river floods are not at all only theoretical menaces. People in the Netherlands suffered in course of centuries really a big number of very severe inundations with many times a high loss of life and land.

The most recent inundations were those of 1926, caused by a big river flood and those of 1953, caused by the very disastrous North Sea stormsurge, known as the catastrophical Holland flood.

What in this country is done to prevent against as well as protect against will be described separately for river floods and for stormsurges in the sphere of engineering responsibility.

RIVER FLOODS

2. Situation

The Netherlands consist of the delta of Rhine and Meuse, as shown in Fig. 1. Lobith is the station where the Rhine enters our country. It is the key station for all information required. The shaded areas are lower than the height of the floods. They consist of very good agricultural land, are rather densely populated with a lot of villages and smaller towns. These areas are defended against river floods by dikes. Our ancestors were used to build the dikes to the height of the latest flood plus some freeboard. But the method could not take care of the stochastic character of river floods. Moreover no rating curve was at hand and no stable gauges.

3. Decision to a modern design level

For sake of shortness we will confine to the river Rhine, having a catchment area of 160,000 sq.km. The rating curves of discharge have been measured since 1900. So we have daily discharges in cu.m during almost 70 years now. Fig. 2 shows the yearly maxima up to 1968.

These maxima may be placed in order of magnitude on a linear scale, the order or number being placed on a logarithmic scale: Fig. 3.

The line of excess represents the physical state of the catchment. There is no evidence for any scale whatever to give an adequate representation. So we prefer a logarithmic scale, being a very simple and handy one(1).

The lower part of the curve is well fixed by the observations. For the highest 3 or 5 observations the place and the direction of the curve is not so definite. It must be stressed here that the highest value cannot be connected to a period. The period of observation of the highest flood has no well defined beginning and no well defined ending. So the frequency of the highest value observed is unknown. In the graph has to be put a horizontal line and not a dot. The third part of the frequency curve is the extrapolated part. This part is fully disputable as to the direction, to the shape and to the place. But the arguments can only be physics, not mathematics. Working in this way we never find a definite value, which could represent a highest possible flood in the absolute sense of the word. Any high value can be overtopped by a still higher value, but with a smaller chance of occurrence. Obviously one has to renounce fully from the possibility of fixing a highest possible flood and to turn all attention to the question: what is an acceptable risk?

For the river Rhine an acceptable risk has been considered by the Netherlands government to be 3% in 100 years. This is equal to a chance of 0,0003 py(2). From the frequency curve we read off the design flood in cu.m. The next task is to calculate in what way the river can carry off the design flood. The water level of this design flood is increased only with an adequate margin for wind waves and waves from passing ships, for soil compaction and a smallest reasonable freeboard. No further hidden safety is incorporated. Such a calculation leads to a system of profiles, slopes and heights along the river reach which guarantee the required possibility to carry off the design flood without difficulties and without risks. When an extremely high flood overtops the design flood with only a few centimetres, this will not result automatically in a disaster. The overtopping must last enough and must coincide with other unfavourable circumstances (duration, heavy rainfall on the dikes, high wave action a.s.o.) to lead to a dike burst. So the chance of a disaster is notably smaller than the accepted risk of overtopping. If we suppose an overtopping of the design flood with less than 10% will cause perhaps serious damage but not to result in a dike burst, then the risk of real flooding is reduced to 10^{-4} py.

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(1) Ir. J.W. van der Made: Assessment of a design discharge of a river, symposium of Leningrad 1967, publication No. 84, International Association of Scientific Hydrology.

(2) This sophisticated value has no scientific significance but a political background. After 0,0001 py had been ordered by the government as the design risk in the coastal areas shortly after 1953, see Ø 9, a value had to be stated some years later as a design risk for floodings from Rhine and Meuse. The latter being surely less fatal than floodings in the very low lying districts by salt water from the sea, Ø 8, no difference could not be accepted. A "higher" risk had to be stated as being acceptable. A difference of a factor 10 has been regarded as too high. A factor 3 has been accepted without further discussion.

4. Watching

The river Rhine divides in the Netherlands into three branches and together with the river Meuse some 600 km dikes are required to protect a width up to 30 km from being flooded. At present the height and construction of these dikes are adequate to floods of 1 to 50 or even to 200 years return period. This is considered to be insufficient and extensive works are being in execution to increase the safety. This will take many years however but during this period we are not passive against this lack of safety. Four systems are active to compensate that lack, being:

(a) a continuous watching of the daily water stages on the rivers and its tributaries (paragraph 4);

(b) a method of forecasting (paragraph 5);

(c) a warning system (paragraph 6)

(d) a dike defence (paragraph 7).

The watching is a routine job. Every day are received by telephone the heights of 40 selected stations: Fig. 5. The same information is used for broadcasting in order to inform shipping. This double use has the advantage that the system is always active and proceeds already a century without one day missing. As a part of this routine work graphs give day by day information about the runoff conditions throughout the catchment. Fig. 7 shows all important floods as has been observed since 70 years of observation.

5. The forecasting

If there is a sudden rise the forecasting starts immediately. This forecasting is based on the observed levels by transforming the levels into discharges and adding the discharges, taking into account the time lag.(1). Fig. 8 shows, that we can use the discharges of the main tributaries up to 4 days in advance as an indicator. For a number of keystations the hydrographs are continuously constructed with a small extrapolation over 1/3 or 1/2 day. Starting then with the most distant keystations we calculate the magnitude of the flood after 1, 2, 3 and 4 days. As tools we use the already mentioned hydrographs, rating curves, travelling times from one keystation to the next and forms, as shown in fig. 9.

The method gives automatically the forecasting of all the keystations along the river. So Worms 1 day before, Kaub 2 and 1 day before, Cologne 3, 2 and 1 day before and finally Lobith 4, 3, 2 and 1 day before. The result is a curve of expected waterstages, giving information for tomorrow and three days after tomorrow. The latter being of course only a rough indication.

6. The warning system

The forecasted levels are now compared with three important levels which may be named A, B and C. If it is expected, the lower level A will be exceeded, the warning system starts. If it is expected that level B of a "serious flood" will be exceeded, the command is despatched to start dike protection to a still restricted extent.

If it is expected that the level C of a "dangerous flood" will be exceeded, the command for extensive protection is despatched.

There is a level A_r valid for the river Rhine and another A_m valid for the river Meuse. There are levels B_a, B_b, B_c etc. and levels C_a, C_b, C_c etc. for each riverreach. For the different riverreaches differ substantially one from the other. And one flood differs fundamentally from others on account of its height, its time history, its dynamics.

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(1) ir. P.J. Wemelsfelder: "Daily stage forecasting on the Rhine", proceedings International Navigation Congress, Tome 1954.

The forecastings and warnings are directed by telegram, telephone and telex to the authorities, in charge of protection aspects. By radio twice every day a description is given of the overall situation.

7. Dike protection

The command of limited protection or of extensive protection for one or more reaches of the river is given by the Minister of Public Works. The whole organisation is permanent. The manpower concerned consists mainly of technical personnel of the boards, normally in charge of riverworks. Materials and utensils are everywhere at disposal in special stores. The competence of the local protection units is very high, in order to bring immediately into execution every precaution to cut down perilous developments. There is however a technical hierarchy, mainly to give as soon as possible adequate assistance if in any region a critical situation will be actual.

This assistance can be given by special troops of the army, as well as by contractors. Both are consigned in advance by the already mentioned general command of the Minister. Only one decision is sufficient to bring the whole organisation into action on every arbitrary day or night of the year.

STORMSURGES

8. The menace of stormsurges at the coast

The Netherlands enjoy a very good as well as a very bad situation at the North Sea. As to surges the situation is a very bad one, due to four unfavourable items.

First: the land, bounded to the sea, is over a width of 60 km lower than surgeheight, even lower than mean sea level (Paesi Bassi). Partly to depth of 4 and 5m below. So failing of the sea defence system can result in most disastrous inundations.

Second: the sea penetrates into the land by great estuaries. This increases the vulnarability of the country with a large factor.

Third: In this area are living 6 million people in well known towns as Amsterdam, Rotterdam, the Hague and a great number of smaller towns and villages. All these inhabitants are more or less continuously threatened if at any time or at any place the defence system against the sea should fail.

Fourth: the menace of the sea is not at all only a theoretical one. Every storm can turn out in a serious disaster, for there is in every winter a number of storms with a path of the low just north of our country. Such a path can be a more or less critical one, piling up the waters of the North Sea to the closed end of that sea, where the Netherlands are situated, fig. 12.

9. Decision to a modern design level

Since more than 100 years we dispose of daily records of sea level. Fig. 13 shows the stochastic time history of the yearly maximum surgeheight in one station. Investigation of the surgeheights has learned the laws of this phenomenon.

The most useful presentation of the whole universe of storm surges is the well known exceedance curve: fig. 14. The heights are placed on a linear scale, the frequency on a logarithmic scale. This is done only for sake of simplicity. Such a curve is composed of two parts. A lower to the left, which part is fairly fixed by the observations.

The other part of the curve is the extrapolated one to the right. It is the part for heights, which occur less than once in a span of time equal to the period of observation. There are consequently no observations available to determine place, shape and direction of the upper part of the frequency curve. And of course there does not exist any theoretical basis which could replace the lack of observations.

So this second part of the exceedance curve only can be drawn by making assumptions. The following assumptions bear some likelihood.

(a) a continuity between the first part of the curve and the second part;

(b) the curve will surely not continuously increase in steepness;

(c) the curve will not emphatically bend off to a limit;

(d) the part of the curve above a frequency of $10^{-5}/y$ is not higly interesting for the question of safety. $10^{-5}/y$ is equal to a chance of 1 percent in 1,000 years. So some uncertainty in this region of the curve does not enter into our consideration.

Of course there is no physical law that should compel nature to present a straight curve on any scale, whatever that may be. So we are free to choose a scale on the basis which serves us best. After our opinion this is the well known logarithmic scale for its simplicity, suitability and efficiency. In our situation the frequency curves of stormsurges are practically straight or only weekly curved on this logarithmic scale.

Fig. 14 shows the height of the disastrous stormsurge of 1953, which flooded 540 sq. km of high populated land and drowned 1,800 people. The height of this surge is found to be once in 300 years. It was 70 cm higher as has been registered before over 150 years of regular observations.

This disastrous surge compelled to redesign the margin of safety of the defence works along the sea coast. So the question arose: what is an acceptable risk. That proved to be a highly complicated matter of technical, human and economic aspects. After thorough investigations and discussions as an acceptable risk has been accepted a surgeheight which should be exceeded less than 10^{-5}/y. So the design level has been fixed on the frequency of 10^{-4}/y.

This is obviously not the risk of flooding land and destroying towns. It is the risk that a surge might overtop the design level. Overtopping the design level will not immediately cause serious destruction of the defence works. A stormsurge ascends rather rapidly to its maximum height and falls rapidly back to a less critical level. The sea level, highly disturbed by tempestuous waves, will not stay longer than only a few quarters of an hour on its highest height. The destruction of well-designed defence works costs time so the overtopping must at least amount to many dm before such a destruction will be disastrous. The risk of flooding land and of destruction of big towns is surely not as great as 10^{-5}/y. So by accepting the height of 10^{-4} as design level the risk of a disaster is as less as 10^{-5} which is equal to 0.1 percent in 100 years. This has been considered as being an acceptable risk.

The present design level is another 1 to 1½m higher as the serious disaster of 1953 has been. For the greater part of our coast this new design level asks for sea defence works of 2m higher than it was before. The improvement of the safety against stormsurges is known under the name Delta Plan. An important part of this gigantic work consists in the closing off of several estuaries from the sea, fig. 15.

10. Watching and forecasting stormsurges

The great plan is now midway of execution. It will be ready about 1978. To compensate the lack of safety during the present years a special warning service and a service for instant dike protection has been organised. In the total organisation 8 quite different functions and 8 different groups of bodies can be distinguished.

The first to be mentioned is the state meteorological service. This service, being in charge of the normal daily forecasting and the daily weather bulletins has a special department for observing day by day every possibility that an approaching low would take an unfavourable path and would develop an unfavourable windfield, which might give rise to a stormsurge.

This department is alert the whole year round and has to make special forecastings at least 15 hours in advance. If such a forecasting indicates a stormsurge situation the meteorological service warms the stormsurge bureau.

The stormsurge bureau of the ministry of public works is the second body to be mentioned. It comes to action as soon as it is contacted by the weather bureau. It compares continuously the meteorologic information with the development of the surge in time and in space along the coast, being at disposal in the office by telerecording. The stormsurge interferes with the normal tidal motion. Only the addition of astronomical high water and surge effect can lead to a stormflood. If the astronomical tide is not so high, for instance, at neap tide. If the surge effect is not great and if the maximum of it does not coincide with highwater, the resulting effect will often be unimportant. No warning is necessary. But if the astronomical tide is high, for instance, at spring tide, if the surge effect is great and if the maximum of it coincides with highwater, then the resulting effect may be serious.

11. Locating and warning

To know whether a forecasted height is serious there are in a special station 2 levels valid: a lower level and a higher level. If it is expected that only the lower level L will be touched, a telegram L will be despatched. If it is expected that the higher level H will be touched or exceeded a telegram H is despatched. In figure 16 the observed sea level just touches the level H of extensive surveillance.

A given station can only be representative for a relatively small reach of the coast. For the astronomical tide alters considerably along the coast in height as well as in time, and the stormsurge is a highly dynamical process giving a time history which is highly different from place to place. Though the length of our coast is only 400 km it has proved to be necessary to have at least 4 keystations, each valid for an additional district, fig. 17. Each district has its own warning levels L and H. If for any district the level L or even H is expected to be exceeded a warning telegram L or H is despatched to all people concerned in that district. In the case of a really big flood there are often more telegrams in succession; for the districts are hit by a surge in succession, always in the direction south to north. Those telegrams are often different.

The warning telegram must be despatched as early as possible, but at least 6 hours in advance of the moment of highwater. These 6 hours are urgently needed to despatch the telegram and for the mobilisation of the dike watch. The forecasting itself is then based on the meteorological situation of another 4 hours earlier; so there is a period of 10 hours between forecasting and realisation. Moreover the meteorological information is only spotwise in time as well as in space and often incomplete (Northern area) and our theoretical knowledge of the interaction of wind and tide deficient. So it is self evident that there is a deviation between forecasting and realisation, so often a stormsurge is much more serious than has been forecasted, or in the reverse: there has been warned for a serious or even dangerous flood and a minor flood comes to realisation. This wolf aspect is a highly precarious aspect of the system. Up till the present moment we have no solution for this serious inconvenience.

All people who have to receive the warnings are known by the warning bureau. The lists are systematically checked every year and after that put in the hands of the GPO (=PTT) who realises the despatch instantly at every day of the year and at every hour of the day: so the GPO is the third body in the general organisation. Of course we also make use of the radio, but it is impossible for the officials concerned to listen 24 hours a day, day after day to possible warnings. The telegram system has the advantage of efficiency as well as security; for it is important that everyone in charge of defensive work, really receives the warning personally in the office as well as at his private address during the night. Of course, every person concerned has a second man on the list.

12. The receivers of the warnings

The warning telegrams go to different groups, being:

(a) the local waterboards normally in charge of normal maintenance and supervision of their own sea defence works. They first have the task of watching and fighting dangerous attack by the sea. They know their own situation by practice and they are personally directly interested in the question of safety.

(b) Secondly, the warnings are directed to all directly concerned personnel of the technical staffs on regional, provincial and national scale. They give the necessary directions for the work to be done and provide the integration of the work.

(c) The third group of receivers are some special bodies of the army, designated to offer in case of emergency help on military scale in the technical sector. After having received the warning they stay ready for immediate assistance to the higher officials.

(d) The fourth group of receivers are the civil defence organisation. The civil defence organisation has a task in case of real flooding not to fight against the sea, but to give assistance to the governmental authorities in the locality: assistance to the police, guarding, administration, traffic.

(e) The warning goes also to the National Red Cross. The Red Cross is in charge of giving help to the touched population directly: evacuation, transport of people, lodging, food supply, the care of children, patients and the ancients.

The whole organisation looks perhaps complicated, but in reality it is a very simple one. The task of everyone is strongly related to his normal task. All services concerned are permanent and have tasks well defined and well separated one from each other. The organisation is highly efficient and can come to action at any moment, day or night.

It is only the central warning telegrams that is special and just this telegram links all services closely together. For they all come simultaneously into action for the same announced stormsurge and can do no better than work closely together to attain the aimed protection, help and assistance.

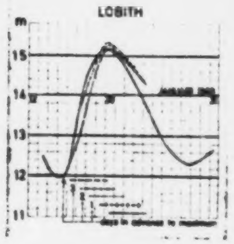


Fig. 10. The forecasting anticipates the development of the riverstage.

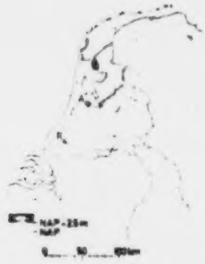


Fig. 11. The shaded area is lower than surge height, the dark shaded area even lower than normal high water partially up to 5 m. below mean sea level.

Fig. 12. The Netherlands, continuously menaced by storm surges on the North Sea.

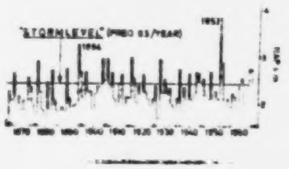


Fig. 13. Time history of the yearly maxima of surge height in one station.

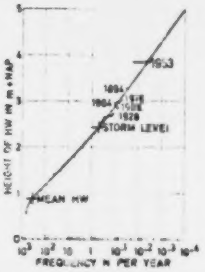


Fig. 14. Exceedance curve of stormsurge heights.

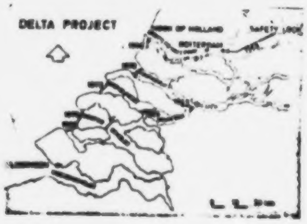

DELTA PROJECT
HOOK OF HOLLAND
ROTTERDAM
SAFETY LOCK

Fig. 15. Delta plan in the south-west part of the coast.

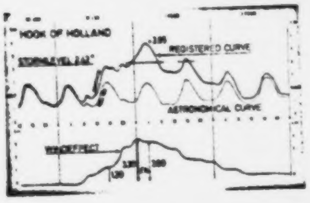


Fig. 16. Time history of the normal astronomical tide, the wind set up curve and the resulting observed sea level.

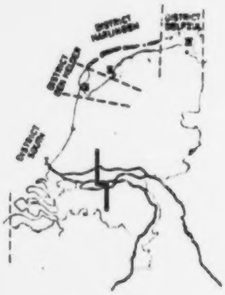

DISTRICT HARLINGEN
DISTRICT DELFZIJL
DISTRICT DEN HELDER
DISTRICT

Fig. 17. Subdivision of the coastal region into four districts with each a special key-station.

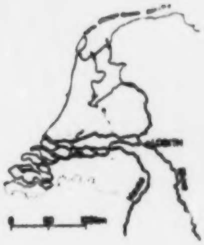


Fig. 1. The delta of Rhine and Meuse. The shaded areas must be defended against river-floods.

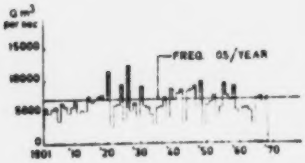


Fig. 2. Yearly maximum floods of the river Rhine at Lobith over the period 1900-1968.

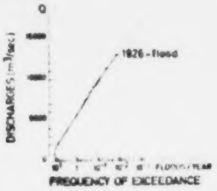


Fig. 3. Exceedance curve of the yearly maxima of the Rhine at Lobith.

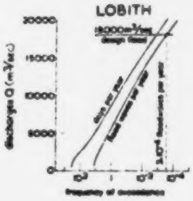


Fig. 4. Starting from an acceptable risk of 0.0003 py, the extrapolated frequency curve indicates a design discharge.

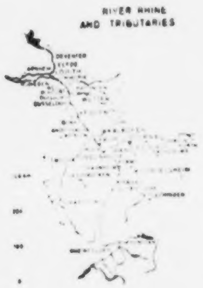


Fig. 5. Daily information of the waterheights of 40 gauges being 25 of the Rhine itself and 15 of its tributaries.

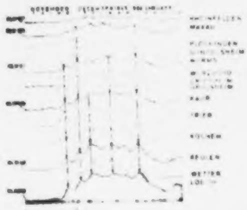


Fig. 6. Hydrographs of the river Rhine from day to day constructed on a routine basis.

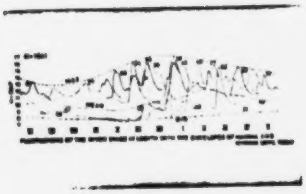


Fig. 7. All important floods, observed in Lobith from 1900 to the present.

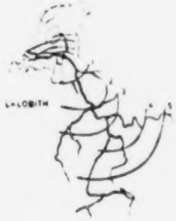


Fig. 8. Travel time of floods in the Rhine catchment in days, related to Lobith.

Fig. 9. Forms for the forecasting of the discharge over 1, 2, 3 and 4 days.

CCMS No. 2

LAND DRAINAGE AND FLOOD PROTECTION IN ENGLAND AND WALES

Responsibility

Responsibility for land drainage and flood protection is vested in river authorities, internal drainage boards and local authorities.

River authorities are responsible for the larger rivers and for many miles of their tributaries (designated for this purpose and known as "main river"). They are also responsible for exercising a general supervision over the drainage of their catchment areas. River authorities are multi-purpose river basin authorities.

Within the 29 river authority areas there are some 370 internal drainage boards set up to deal with special local problems.

Local authorities (county councils, county boroughs and county district councils) have limited land drainage and flood protection powers of their own.

All three types of authorities are responsible for necessary improvement schemes.

The Ministry of Agriculture pays grant towards these improvement schemes and is in effect the parent ministry for land drainage purposes.

Types of floods, design of schemes, planning consideration, economic factors, etc.

An account was given at the meeting of these topics.

Flood warning schemes

Flood warning schemes are operated by river authorities. The techniques employed and instrumentation of these schemes depend on the size and nature of the catchment areas concerned.

The Ministry of Agriculture sponsors a national flood warning system in relation to tidal flooding on the East Coast of England because of the dangerous conditions caused by surge tides.

The Ministry of Agriculture also operates a special tidal flood warning system for London.

Action in times of floods

The river authorities and other drainage authorities are responsible for emergency activities in relation to drainage works, for disposal of flood water, etc.

The safety and rescue of the public is a matter for the police forces. The welfare, housing and feeding of people affected by floods is the concern of local authorities.

The operations mentioned above are co-ordinated locally but in the event of a disaster of magnitude the Central Government gives assistance. Where the flooding is of disastrous proportion the Central Government exercises the required extent of national co-ordination.

A measure of contingency planning is done both at local level and at Government level. The Ministry of Defence makes available resources of men, plant and materials.

CCMS No. 2

LONDON AND EAST COAST TIDAL FLOOD WARNING SYSTEM

by G. Cole (United Kingdom)

I. THE EAST COAST SYSTEM

Origins

The East Coast Tidal Flood Warning System has its origins in the disastrous coastal floods of 31st January - 1st February, 1953, which caused some 300 deaths and did an estimated £30 million worth of damage. (In the Netherlands the disaster was even more severe and nearly 2,000 lives were lost.) The geographical background to these floods is the juxtaposition of the restricted waters of the North Sea and the low-lying marsh lands of the East Coast, protected for the most part by earth embankments, the tidal length of which is in the order of 1,200 miles. Central Government responsibility for the protection of these areas lies with the Ministry of Agriculture, who immediately following the disaster sought the advice of the Admiralty Hydrographer's Department and accordingly set up a jointly operated warning system. Although the storm had passed, the presence of numerous breaches in the defences meant that danger was ever present, and contractors working on foreshores had to be protected.

Because of the meteorological origin of this kind of flooding and the need for a communications network, the permanent service, when it was set up a few months later, was installed at the headquarters of the Meteorological Office, now at Bracknell some 30 miles to the west of London.

Formation of East Coast surges

Storm surges are caused by wind stress on the surface of the sea and by barometric differentials. The maximum variation due to the second of these seldom exceeds a foot, and the friction effect is by far the more important. It can be demonstrated in an enclosed flume, in which the still horizontal surface of the water assumes a slope under the action of fans. The North Sea surge has internal and external components: winds from the westerly sector can cause an increase in height to the north of Scotland and at the northern entrance to the North Sea; northerly and north-easterly winds make the North Sea behave rather like a flume. If the wind veers these can follow one another so as to give a cumulative effect on the East Coast.

The time of travel of the surge down the East Coast is roughly the same as that of the tide, taking about 11½ hours to travel from Aberdeen in Scotland to Southend at the mouth of the Thames. It then proceeds round the Belgian and Netherlands Coasts. There is an amphidromic point in the southern North Sea between the Netherlands and east East Anglia.

There is considerable advantage in being able to detect the surge at more northerly ports and information of dangerous conditions is passed by the British Storm Tide Warning Service to the Netherlands. A synoptic situation leading to a storm surge is illustrated at fig. 1.

Organization

The Storm Tide Warning Service is operated by the Hydrographer of the Navy on behalf of the Minister of Agriculture, who is answerable for all questions of flooding other than those connected with storm water sewerage. Officers of the Service at their headquarters at Bracknell are equipped with repeater tide gauges which continually reproduce the analogue record from gauges at Stornoway, Wick, Aberdeen, Tynemouth, Immingham, Lowestoft, Walton-on-Naze and Southend. The information is transmitted by continuously occupied telephone lines, but in the event of failure readings are transmitted orally.

Warning information is addressed jointly to river authorities, who are the local authorities directly responsible for the sea defences, and the police in their areas, but because not all river authorities are on the telex network, messages go directly from Bracknell to county police headquarters and the police pass them to the river authorities by the quickest means, usually telephone. From this stage the river authorities monitor the situation locally by means of their own gauges, and the police, whose responsibility is the protection of life and property, act on their advice. Contingency plans have been produced by the police and river authorities in consultation with local government.

River authorities make an annual review in conjunction with the armed forces to ensure that each has adequate knowledge of likely needs and available military equipment. In the event of greater demands for military assistance than can be met immediately the War Office seems the advice of the Ministry of Agriculture. The Ministry is not, however, responsible for the protection of life and property and is not therefore concerned with detailed contingency planning, although it is prepared to assist in organizing the supply of men, machines and materials to river authorities. Moreover, although no rôle is formally laid down for it following a flood it usually plays a leading part in organizing the reinstatement and improvement of the defences. For the 1953 floods an ad hoc Act of Parliament was passed.

Forecasting methods

Warnings are issued at 12 hours and 4 hours before the predicted time of high water or, in the latter case, 4 hours before the attainment of danger level if this is expected to occur earlier. Danger levels are locally agreed levels that have been submitted to the STWS.

The 12 hour warning is merely a warning that meteorological conditions are such that flooding could occur, and is based on an inspection of the synoptic charge plus an approximate computation of the likely effects of barometric differentials and wind speeds according to the barometric gradient. Subsequent warnings (4 hours) are based on observed residuals (observed tide minus predicted tide) and heights forecast from regression equations. Formulae have been derived giving heights solely as functions of wind velocities and directions at offshore stations, and also incorporating, in addition, residuals at more northerly stations. Accuracy is generally in the order of about ± ½ foot, the standard error being .4 foot and a maximum error being about 1½ feet.

To distinguish between marginal and more dangerous situations the 4 hour warning has been sub-divided into 2 classes: a "danger" and an "alert confirmed", the 12 hour warning being the "alert". The phrase "alert confirmed" is used when it is expected that the tide will be within ± ½ foot of danger level. The 4 hour warning is accompanied by a forecast of wind speed and direction.

Research

An Advisory Committee on Oceanographic and Meteorologiaal Research was set up in 1954 with the purpose of supporting the practical work of the flood warning organization. It has leaned heavily on the work of the Institute of Coastal Oceanography and Tides (ICOT) - formerly the Liverpool Tidal Institute - and the National Institute of Oceanography. Their work has taken two main forms: the derivation of empirical formulae by statistical analysis and the investigation of the dynamics of storm surges. ICOT has also done work to improve the quality of the tidal predictions.

Great improvement in accuracy has been elusive, but the work done on surge dynamics with mathematical models is promising and highly interesting. ICOT produced two digital models: one of the North Sea and another of the Thames Estuary, and these have now been linked up. NIO devised an analogue model (1). The ambition is to use the models on line, and hindcasting tests are being carried out to this end. The broad basis of both is to enter the model with wind velocities and directions at points on a grid over the North Sea and to obtain residuals at reference ports on the coast as output.

Work by ICOT and the UK Ordnance Survey also continues on mean sea level. A general rise on the East Coast in the order of a foot a century has been indicated. In the Thames Estuary it is somewhat larger. A Working Party of the Oceanographic and Meteorological Committee has steadily improved the quality of tidal recording.

II. THE LONDON SYSTEM

Origins

A disastrous flood overtook London in 1928, following which the defences were raised and a simple warning system was established. A bell rang automatically in the harbour master's office at Southend when the tide reached the fairly low danger level of 12.1 above Ordnance Datum. This was used mainly to alert police, who then watched marker boards and warned the public when the tide reached certain levels. Folllowing the 1953 flood (which fortunately did limited damage in London) this system was incorporated in the general East Coast system by using the same level as a basis for warnings from STWS at Bracknell to the Metropolitan Police and the London County Council (now the Greater London Council). In other respects the system remained broadly the same. In 1968 publicity following discussions on proposals to erect a tide-excluding barrier across the Thames, and the government's own concern, lead to a re-examination of the London system, as a result of which the Ministry of Agriculture took over direct control, although operating in collaboration with the Greater London Council.

Components of surge tide levels in London

In addition to the North Sea surge, levels in the Thames Estuary can be augmented by winds in the southern North Sea; and the fluvial discharge of the Thames over Teddington Weir, 18 miles upstream from Central London, has a variable effect, usually measured in inches but in the limit reaching 1½ feet.

Organization

In London the GLC and Metropolitan Police would normally play the same part as the river authorities and police in the provinces, but this is modified to the extent that the Ministry of Agriculture is running the London Flood Warning System in place of the GLC, although with its collaboration. As in the provinces, 12 hour and 4 hour warnings are received by the Metropolitan Police by telex from Bracknell and passed on to the GLC.

On to this, however, is grafted a more elaborate local system. The Ministry of Agriculture's Flood Room in Westminster is equipped with a continuous tide gauge repeater for Southend backed up by repeaters for Tilbury (as an emergency supplement to Southend) and Tower Pier (as an indicator of actual levels in Central London). As a first line of defence against the failure of the Southend repeater, however, it has a direct telephone link to the Port of London Authority at Gravesend, on the south bank of the Estuary, where another direct repeater of the Southend levels exists. As a final defence, readings can be obtained by telephone from Southend.

The Flood Room also has a direct line to the STWS at Bracknell, (which gives yet another means of obtaining Southend readings), and there is a teleprinter link between the Flood Room and the HQ of the Metropolitan Police at Scotland Yard about half a mile away. This is normally used only for the transmission of pre-punched tape messages and is supplemented by a direct telephone line. Because of the vital importance of the underground railway network a direct line is maintained for the purpose of outward messages to London Transport Executive. (LT consider that if the underground were seriously flooded it would be out of action for something in the order of 9 months, apart from a skeleton service.)

As in the case of the river authorities the Ministry, acting for London, advises the police on the issue of warnings, and this it does by means of the pre-punched tape messages which have been agreed with them. Although the defences of Central London are more vital to the life of the capital, the defences upstream from West London to Teddington Weir are lower, and this has the effect of dividing the system into two parts and making it necessary to issue warnings earlier and more often for the less vital part upstream.

The system has been arranged so as to give the necessary flexibility for a tide running early, but it is convenient to describe the situation that occurs with the smaller surges, which usually run to time. (The principal difference is that timings with a larger surge are all related to the time of achievement of danger level at Southend: with the smaller surges this coincides more or less with the time of predicted high water.)

The Flood Room is manned if an "alert" from Bracknell is still in operation at such time as will permit officers to open-up the Flood Room 4½ hours before high water at Southend. From that time onwards the actual tide is plotted and regular contact is maintained with Bracknell.

If a dangerous situation is indicated as late as three hours before high water at Southend (which is 4 hours before high water in Central London) a general warning is sent to the police who, through their divisions, warn a short list of about a dozen authorities who need to take advanced action. These include for example the Post Office and the power authorities. An hour later the same thing is, if necessary, done for the upstream sector.

If the situation persists, a second warning is sent in the case of Central London by the same route and local authorities are warned to have their emergency services standing by. One of the main aims of this is to prepare for the evacuation of the aged and infirm, but no public warning is issued at this stage. The time of issue of this warning coincides approximately with that for the first upstream warning.

Finally, if the situation has not abated, the seal is broken on its container and a tape is sent through the teleprinter reading, "Flooding expected in approximately 1 hour. Sound flood warning sirens now." On receipt of this sirens are sounded throughout the Central London floodable area by the operation of a keyed switch in Metropolitan Police Headquarters at Scotland Yard. The equivalent executive action upstream is taken, not by sirens, but by police on patrol.

Contingency plans from this stage onwards are in the hands of the London boroughs, which are autonomous within the GLC area. GLC, through the borough welfare officers, has achieved a measure of co-ordination, and central government (Department of Health and Social Security) is now giving these plans further study. As with the East Coast system, the Ministry of Agriculture does not have a formal rôle beyond the flood warning stage, but it is prepared to play the same part as it has played in other large floods in the past. Similarly, although the GLC is a large and well-equipped organization that should have sufficient muscle to take care of all flood rehabilitation works, the Ministry of Agriculture would nonetheless probably be required to play a co-ordinating rôle.

Forecasting Method

The risk of crying "wolf" is inherent in all warning systems, but the Ministry have had its avoidance as a primary object in the case of London. On taking over they discovered that the police had an enormously long list of people who claimed that they needed advanced warnings, and by strenuous efforts the length of this list has been reduced by several hundred per cent. But the most potent means of reducing the number of warnings has been to delay their issue as long as is compatible with the time required to take action, and clearly no improvement in this respect can be obtained over a system which does not warn the public until the dangerous tide has actually arrived. This is what happens when the sirens are sounded on the attainment of danger level at Southend. Under these conditions, if the danger level at Southend were just attained and no more, it is expected that the top of the defences would be just overtopped in Central London, although a considerable amount of flooding would occur upstream. It is possible that there might be isolated breaches and some flooding would be caused by the backing-up of sewers and similar causes.

Before the order is given to sound the sirens the height of tide as recorded on the repeater is compared with that obtained by telephone direct from Gravesend. In the event of failure of the Flood Room a "fail safe" system is provided by the 12.1 bell and a further bell at Southend at a level of 13.6 which warn Scotland Yard of the attainment of dangerous levels. The police can then operate the emergency services standby and the sirens can be sounded. The upstream area can be similarly warned. Preliminary warnings are, however, not possible.

The magnitude of the discharge over Teddington Weir is received from the upstream river authority (the Thames Conservancy) daily when flow exceed 1,000 mgd.

Research

The research described under the East Coast Service is also available in support of the London system, but in addition work has been done in support of the Thames Barrier project by ICOT, and the Hydraulics Research Station of the Ministry of Technology has provided information on frequencies and stage relations. Pioneer work in connection with the Thames Berrier was done by Otter (2).

III. HISTORY AND FREQUENCY

The East Coast has suffered from tidal inundations down the centuries. The classic case is the final inundation of Earl Goodwin's "fair acres" in the 11th century: these are now the treacherous Goodwin sands. Disastrous flooding occurred in London in 1881 and the tide reached within about half a foot of bankfull in Central London in December 1965. Some places on the East Coast have had levels since 1953 that were higher than on that occasion: Farquharson (3) has stated that one of the peculiarities of 1953 was not so much the levels attained as the fact that they were attained over so great a length of coastline.

Frequencies for a number of important places on the East Coast have been computed by Suthons using the method of Jenkinson (4), and the 1953 flood was considered until recently to have a frequency of about once in a hundred years. This allowed for a steady rise in main sealevel relative to the land of about a foot a century, but in London further anxiety has been caused by the discovery of an additional effect, confirmed by Rossiter. The only explanation that has been offered is that it is a hydrodynamic effect deriving from the fact that more water is entering the Estuary as a result of the relative rise in main sea level. Taking account of the fact that improvements to the defences downstream have reduced the risk of overspill (thus slightly increasing levels upstream of the breaches) the total rise is now put at something in the order of 3 feet a century, and in London the frequency of 1953 levels is in the order of 10 years. One foot above bankfull may have a frequency in the order of once in 40 years and 2 feet above once in 100 years. Three feet above would be the 400 year flood.

IV. THE FUTURE

The most sophisticated improvement likely in forecasting seems to be a use of real-time models. Unfortunately, no great improvement in accuracy is yet in sight. The Thames Barrier presents peculiar forecasting problems insofar as its operation must inevitably cause some disturbance to shipping, and delayed closure could under certain circumstances so enhance tidal levels downstream as to cause flooding. It does not seem beyond the bounds of probability that the barrier could, if necessary, be operated without human intervention as far as the flood warning aspect is concerned. For the East Coast generally economics are likely to militate against making the defences impregnable even against relatively high-frequency tides, and a permanent warning system would seem to be a necessity.

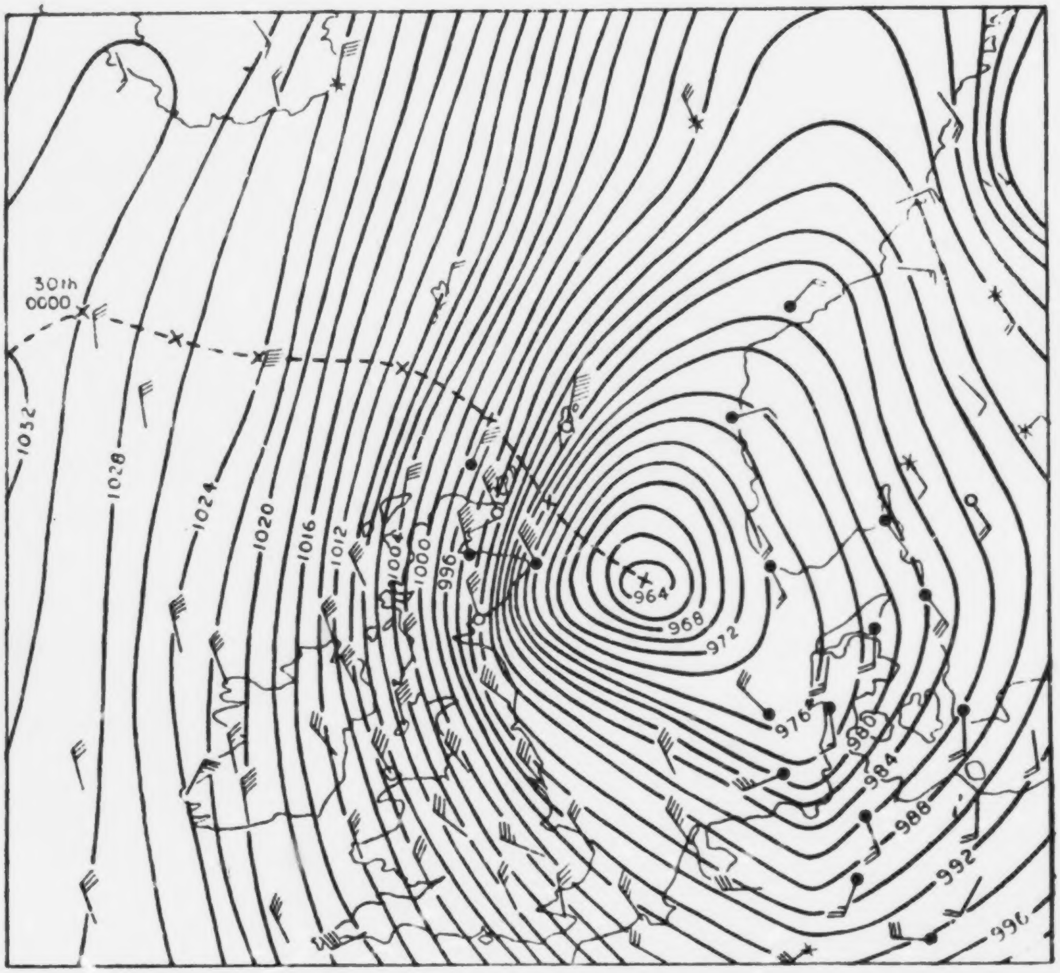
V. REFERENCES

(1) Advisory Committee on Oceanographic and Meteorological Research: unpublished papers by Banks, Heaps and Ishiguro.

(2) Otter

(3) Farquharson, W.I.: Storm Surges on the East Coast of England. IN Proc Conference on North Sea Floods of 1953 Inst. CE 1954.

(4) Suthons, C.T.: Sea Levels on the East and South Coasts of England. IN Proc.Inst. CE, Vol. 25, page 433, August 1963.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31st January, 1953. 12.00 G.M.T.

The wind arrows fly with the wind and each feather indicates *two* points on the Beaufort scale of wind force, whilst a half-length feather is *one* point on that scale.

● denotes rain ; ○ denotes sleet ; * denotes snow

FLOOD PLAIN PLANNING AND FREQUENCY STUDIES

by G. Cole (UK)

It is submitted that in planning for flood mitigation, provided that due allowance is made for human safety and well-being, the conservation of resources should be paramount. It follows that all possible courses ought to be considered and the alternative chosen which gives the best relationship between benefit and cost, due weight being given to social factors. This implies flood plain management.

Intelligent economic choice and flood plain management require an acceptable estimate of flood frequencies, and there is still sufficient uncertainty about the subject, particularly in the matter of the longer return periods, to justify further urgent study. Regional analysis by the index flood method places a useable, if approximate, tool in the hands of engineers fairly rapidly. A refinement of this assesses the index flood by multiple correlation. Recent work by Jenkinson(1)(2) suggests that where meteorological statistics are available for an appreciably longer period than stream gaugings regional analysis of rainfall could be more helpful. Further attention might also usefully be given to the work of Kalinin and Nikolskaya(3).

The choices open in flood plain planning are:

- flood protection schemes;
- flood proofing;
- flood plain zoning;
- flood warning systems; and
- insurance.

Zoning seems to be neglected. It is remarkable that more attention has not been given to it, considering that most hydrologists and flood protection engineers believe flood plain development to be the root of all evit. It may be objected that it is inhibited by the scarcity of building resources, but this does not seem to be a problem because resources at present being put into flood protection works would be released. Expansion of building would be facilitated by the similarity of the two industries.

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(1) Jenkinson, A.F.: Unpublished report to Hydrology Committee, National Environment Research Council, 1970.

(2) Jenkinson, A.F.: Estimation of Maximum Floods. WMO Technical Note No. 98.

(3) Kalinin, G.P. and Nikolskaya, N.V.: Spatial and Temporal Analysis of Maximum Runoff. UNESCO International Symposium on Floods, Leningrad, 1967.

It is suggested that insurance is not a solution because it merely locates the burden of flood damage expenditure without reducing it. US House of Representatives Document 465(1) and the trend in the United Kingdom both appear to be towards its localization. This seems likely to lead to more, rather than less demand for the burden to be transferred to the public at large in the form of flood protection schemes, although House Document 465 considers that it would be useful in making occupants of flood plains conscious of the cost.

The strongest inhibition to the conservation of resources in flood mitigation seems to be that those at risk and those who pay are not the same (or are only partly so).

There seem to be two solutions:

(a) the burden could be borne by those at risk, thus forcing on them the necessity to find the most economic solution; or

(b) the community at large should declare, either by legislation or administrative action, that it requires its money to be wisely spent (having due regard to social factors).

It is submitted that until a solution on these lines is achieved political pressure will continue to be used to divert resources which could be better used elsewhere.

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(1) US House of Representatives Document 465: A Unified National Programme for Managing Flood Losses, US Government Printing Office, Washington, D.C., 1966.

TOWARD A UNIFORM TECHNIQUE FOR DETERMINING FLOOD FLOW FREQUENCIES

by Stewart L. Udall, Chairman
Water Resources Council

In a letter of 10th September, 1966, the Executive Director informed the Hydrology Committee that the Council had assigned it responsibility for developing a uniform technique for the determination of flood flow frequencies. The Hydrology Committee of the Council consists of technical staff members of the Federal departments represented in the Council and of the Tennessee Valley Authority. The Committee devotes its efforts to technical matters in hydrology and has published many hydrologic bulletins that are nationally used.

The Council's assignment was made in conformance with Recommendation 2 of the report by the Task Force on Federal Flood Control Policy, "A Unified National Program for Managing Flood Losses"(1). Recommendation 2 called for the establishment of a panel to examine methods of frequency analysis and to provide a set of techniques based on the best known hydrological and statistical procedures.

In a letter of 20th October, 1967, the Chairman of the Hydrology Committee submitted the Committee's report to the Council. The letter and report contained:

(i) a resumé of the Committee's activities in this field;

(ii) recommendations regarding a technique of flood flow frequency analysis for gaged areas;

(iii) an outline of the recommended base method of analysis;

(iv) appropriate tables of constants for use with the base method; and

(v) a discussion of further and immediate problems requiring the Committee's attention in this field.

The Committee's letter and report were based on the report of the Work Group on Flood Flow Frequency Analysis, an ad hoc work group established by the Committee. Two professional statisticians were employed as technical advisors to the group. The group's main findings were that of six methods tested, three fitted the data well and showed no bias. The recommended base method is one of these three.

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(1) House Document No. 465, 89th Congress, 2nd Session.

In its meeting of 25th October, 1967, the Water Resources Council accepted the Committee's report and recommendations and agreed that they should be published.

Recommendations

The recommendations of the Hydrology Committee are:

"1. The Hydrology Committee agreed that the state of the art with respect to flood flow frequency methods, as with most other hydrologic techniques, has not advanced to the point where complete standardization is feasible or appropriate. For that reason, the Committee recommends that a base method be adopted with provisions for using other methods where adequate justification is presented.

"2. On the basis of current use by Federal agencies, availability of detailed instructions and computer programs, and flexibility in application, the log-Pearson Type III distribution (with the log-normal as a special case) is recommended for adoption as a base method for flow frequencies. In those cases where information exists which indicates some other type of distribution or technique should be employed, such use should be acceptable provided appropriate justification is given. A concise summary of the log-Pearson Type III method is presented in Bulletin No. 13, April 1966, "Methods of Flow Frequency Analysis", prepared under the auspices of the Sub-Committee on Hydrology, Inter-Agency Committee on Water Resources(1).

"3. In view of the importance of flood flow frequency estimates in the expanding field of water resources development and related programs for managing flood losses, continuing efforts by the Hydrology Committee are needed to encourage and co-ordinate efforts of the member agencies in improving existing techniques and procedures in this field. In this connection, the Committee will establish appropriate ad hoc work groups when required for specific tasks; major emphasis, however, will be directed toward bringing such matters to the attention of the full Committee. Some immediate problems requiring attention are outlined in Attachment 4"(2).

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(1) Now the Hydrology Committee, Water Resources Council.
(2) The material in Attachment 4 is given later in this pamphlet under the title "Additional Considerations in Flood Flow Frequency Analysis"

THE BASE METHOD

The Pearson Type III method, as originally presented by H.A. Foster (Ref. 1) in 1924, is described in Bulletin 13 (Ref. 2) in Foster's own words. As used by Foster, the method required the use of the natural data in computations of the mean, standard deviation, and skew co-efficient of the distribution. The current practice, and the recommendation of the Committee, is first to transform the natural data to their logarithms and then to compute the statistical parameters. Because of this transformation the method is now called the log-Pearson Type III method.

Outline of the Method

The following symbols are used in the outline submitted by the Work Group on Flood Flow Frequency Analysis, which based its work on the presentation in Bulletin 13:

Y = arithmetic magnitude of an annual flood event;

X = logarithmic magnitude of Y;

N = number of events in the record being used;

M = mean of the X's;

x = $X - M$;

S = standard deviation of the X's;

g = skew co-efficient;

K = Pearson Type III co-ordinates expressed in number of standard deviations from the mean for various recurrence intervals or percent chance;

Q = computed flood flow for a selected recurrence interval or percent chance.

The events considered here are flood flows in the annual series. (Definitions of hydrological and statistical terms used here are found in the Glossary of Bulletin 13.) In the work, the physical units used for Y (such as cfs) are also those for Q.

The outline of work is as follows:

1. Transform the list of N annual flood magnitudes Y_1, Y_2, ... , Y_N to a list of corresponding logarithmic magnitudes X_1, X_2, ... , X_N.

2. Compute the mean of the logarithms:

$$M = \frac{\Sigma X}{N}$$

3. Compute the standard deviation of the logarithms:

$$S = \sqrt{\frac{\Sigma x^2}{N - 1}}$$

$$= \sqrt{\frac{\Sigma X^2 - (\Sigma X)^2 / N}{N - 1}}$$

4. Compute the coefficient of skewness:

$$g = \frac{N \Sigma x^3}{(N - 1)(N - 2)S^3}$$

$$= \frac{N^2 \Sigma X^3 - 3N \Sigma X \Sigma X^2 + 2(\Sigma X)^3}{N(N - 1)(N - 2)S^3}$$

5. Compute the logarithms of discharges at selected recurrence intervals or percent chance:

$$\log Q = M + K S$$

Take K from Table 1 or Table 2 for the computed value of g and the selected recurrence interval or percent chance. Log Q is the logarithm of a flood discharge having the same recurrence interval or percent chance.

6. Find the antilog of log Q to get the flood discharge(1).

Tables of K Values

Tables 1 and 2 were made from larger and more complete tables prepared by H. Leon Harter (Mathematical Statistician, Wright-Patterson Air Force Base) and the US Soil Conservation Service. Copies of those tables are available, free of charge, from the Central Technical Unit, Soil Conservation Service, 269 Federal Center Building, Hyattsville, Md. 20782.

Computer Program Sources

Federal agencies such as the Bureau of Reclamation, Corps of Engineers, Geological Survey, Soil Conservation Service, Tennessee Valley Authority, and others, have prepared computer programs for the log-Pearson Type III method. These programs are in various computer languages and for various types of computers. Inquiries regarding these programs should be addressed to those agencies.

References

(1) "Theoretical Frequency Curves", by H.A. Foster: American Society of Civil Engineers, Transactions, v. 87, p. 142-203: 1924

(2) "Methods of Flow Frequency Analysis", by the Subcommittee on Hydrology, Inter-Agency Committee on Water Resources: Notes on Hydrologic Activities, Bulletin 13, April 1966. For sale by the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402. Price 35 cents.

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(1) The frequency line can be shown by plotting each Q versus its respective percent chance on lognormal probability paper and drawing a continuous line through the plotted points.

Table 1 -- K values for positive skew coefficients

Recurrence Interval in Years

Skew Coefficient (g)	1.0101	1.0526	1.1111	1.2500	2	5	10	25	50	100	200
Percent Chance	99	95	90	80	50	20	10	4	2	1	0.5
3.0	-0.667	-0.665	-0.660	-0.636	-0.396	0.420	1.180	2.278	3.152	4.051	4.970
2.9	-0.690	-0.688	-0.681	-0.651	-0.390	0.440	1.195	2.277	3.134	4.013	4.909
2.8	-0.714	-0.711	-0.702	-0.666	-0.384	0.460	1.210	2.275	3.114	3.973	4.847
2.7	-0.740	-0.736	-0.724	-0.681	-0.376	0.479	1.224	2.272	3.093	3.932	4.783
2.6	-0.769	-0.762	-0.747	-0.696	-0.368	0.499	1.238	2.267	3.071	3.889	4.718
2.5	-0.799	-0.790	-0.771	-0.711	-0.360	0.518	1.250	2.262	3.048	3.845	4.652
2.4	-0.832	-0.819	-0.795	-0.725	-0.351	0.537	1.262	2.256	3.023	3.800	4.584
2.3	-0.867	-0.850	-0.819	-0.739	-0.341	0.555	1.274	2.248	2.997	3.753	4.515
2.2	-0.905	-0.882	-0.844	-0.752	-0.330	0.574	1.284	2.240	2.970	3.705	4.444
2.1	-0.946	-0.914	-0.869	-0.765	-0.319	0.592	1.294	2.230	2.942	3.656	4.372
2.0	-0.990	-0.949	-0.895	-0.777	-0.307	0.609	1.302	2.219	2.912	3.605	4.298
1.9	-1.037	-0.984	-0.920	-0.788	-0.294	0.627	1.310	2.207	2.881	3.553	4.223
1.8	-1.087	-1.020	-0.945	-0.799	-0.282	0.643	1.318	2.193	2.848	3.499	4.147
1.7	-1.140	-1.056	-0.970	-0.808	-0.268	0.660	1.324	2.179	2.815	3.444	4.069
1.6	-1.197	-1.093	-0.994	-0.817	-0.254	0.675	1.329	2.163	2.780	3.388	3.990
1.5	-1.256	-1.131	-1.018	-0.825	-0.240	0.690	1.333	2.146	2.743	3.330	3.910
1.4	-1.318	-1.168	-1.041	-0.832	-0.225	0.705	1.337	2.128	2.706	3.271	3.828
1.3	-1.383	-1.206	-1.064	-0.838	-0.210	0.719	1.339	2.108	2.666	3.211	3.745
1.2	-1.449	-1.243	-1.086	-0.844	-0.195	0.732	1.340	2.087	2.626	3.149	3.661
1.1	-1.518	-1.280	-1.107	-0.848	-0.180	0.745	1.341	2.066	2.585	3.087	3.575
1.0	-1.588	-1.317	-1.128	-0.852	-0.164	0.758	1.340	2.043	2.542	3.022	3.489
.9	-1.660	-1.353	-1.147	-0.854	-0.148	0.769	1.339	2.018	2.498	2.957	3.401
.8	-1.733	-1.388	-1.166	-0.856	-0.132	0.780	1.336	1.993	2.453	2.891	3.312
.7	-1.806	-1.423	-1.183	-0.857	-0.116	0.790	1.333	1.967	2.407	2.824	3.223
.6	-1.880	-1.458	-1.200	-0.857	-0.099	0.800	1.328	1.939	2.359	2.755	3.132
.5	-1.955	-1.491	-1.216	-0.856	-0.083	0.808	1.323	1.910	2.311	2.686	3.041
.4	-2.029	-1.524	-1.231	-0.855	-0.066	0.816	1.317	1.880	2.261	2.615	2.949
.3	-2.104	-1.555	-1.245	-0.853	-0.050	0.824	1.309	1.849	2.211	2.544	2.856
.2	-2.178	-1.586	-1.258	-0.850	-0.033	0.830	1.301	1.818	2.159	2.472	2.763
.1	-2.252	-1.616	-1.270	-0.846	-0.017	0.836	1.292	1.785	2.107	2.400	2.670
0	-2.326	-1.645	-1.282	-0.842	0	0.842	1.282	1.751	2.054	2.326	2.576

Table 2.--K values for negative skew coefficients

Recurrence Interval in Years

Percent Chance

Skew Coefficient (g)	1.0101	1.0526	1.1111	1.2500	2	5	10	25	50	100	200
	99	95	90	80	50	20	10	4	2	1	0.5
0	-2.326	-1.645	-1.282	-0.842	0	0.842	1.282	1.751	2.054	2.326	2.576
- .1	-2.400	-1.673	-1.292	-0.836	0.017	0.846	1.270	1.716	2.000	2.252	2.482
- .2	-2.472	-1.700	-1.301	-0.830	0.033	0.850	1.258	1.680	1.945	2.178	2.388
- .3	-2.544	-1.726	-1.309	-0.824	0.050	0.853	1.245	1.643	1.890	2.104	2.294
- .4	-2.615	-1.750	-1.317	-0.816	0.066	0.855	1.231	1.606	1.834	2.029	2.201
- .5	-2.686	-1.774	-1.323	-0.808	0.083	0.856	1.216	1.567	1.777	1.955	2.108
- .6	-2.755	-1.797	-1.328	-0.800	0.099	0.857	1.200	1.528	1.720	1.880	2.016
- .7	-2.824	-1.819	-1.333	-0.790	0.116	0.857	1.183	1.488	1.663	1.806	1.926
- .8	-2.891	-1.839	-1.336	-0.780	0.132	0.856	1.166	1.448	1.606	1.733	1.837
- .9	-2.957	-1.858	-1.339	-0.769	0.148	0.854	1.147	1.407	1.549	1.660	1.749
-1.0	-3.022	-1.877	-1.340	-0.758	0.164	0.852	1.128	1.366	1.492	1.588	1.664
-1.1	-3.087	-1.894	-1.341	-0.745	0.180	0.848	1.107	1.324	1.435	1.518	1.581
-1.2	-3.149	-1.910	-1.340	-0.732	0.195	0.844	1.086	1.282	1.379	1.449	1.501
-1.3	-3.211	-1.925	-1.339	-0.719	0.210	0.838	1.064	1.240	1.324	1.383	1.424
-1.4	-3.271	-1.938	-1.337	-0.705	0.225	0.832	1.041	1.198	1.270	1.318	1.351
-1.5	-3.330	-1.951	-1.333	-0.690	0.240	0.825	1.018	1.157	1.217	1.256	1.282
-1.6	-3.388	-1.962	-1.329	-0.675	0.254	0.817	0.994	1.116	1.166	1.197	1.216
-1.7	-3.444	-1.972	-1.324	-0.660	0.268	0.808	0.970	1.075	1.116	1.140	1.155
-1.8	-3.499	-1.981	-1.318	-0.643	0.282	0.799	0.945	1.035	1.069	1.087	1.097
-1.9	-3.553	-1.989	-1.310	-0.627	0.294	0.788	0.920	0.996	1.023	1.037	1.044
-2.0	-3.605	-1.996	-1.302	-0.609	0.307	0.777	0.895	0.959	0.980	0.990	0.995
-2.1	-3.656	-2.001	-1.294	-0.592	0.319	0.765	0.869	0.923	0.939	0.946	0.949
-2.2	-3.705	-2.006	-1.284	-0.574	0.330	0.752	0.844	0.888	0.900	0.905	0.907
-2.3	-3.753	-2.009	-1.274	-0.555	0.341	0.739	0.819	0.855	0.864	0.867	0.869
-2.4	-3.800	-2.011	-1.262	-0.537	0.351	0.725	0.795	0.823	0.830	0.832	0.833
-2.5	-3.845	-2.012	-1.250	-0.518	0.360	0.711	0.771	0.793	0.798	0.799	0.800
-2.6	-3.889	-2.013	-1.238	-0.499	0.368	0.696	0.747	0.764	0.768	0.769	0.769
-2.7	-3.932	-2.012	-1.224	-0.479	0.376	0.681	0.724	0.738	0.740	0.740	0.741
-2.8	-3.973	-2.010	-1.210	-0.460	0.384	0.666	0.702	0.712	0.714	0.714	0.714
-2.9	-4.013	-2.007	-1.195	-0.440	0.390	0.651	0.681	0.683	0.689	0.690	0.690
-3.0	-4.051	-2.003	-1.180	-0.420	0.396	0.636	0.660	0.666	0.666	0.667	0.667

43 - 7

ADDITIONAL CONSIDERATIONS IN FLOW-FREQUENCY ANALYSIS

There are important considerations in flow-frequency analysis beyond the type of distribution that may be used to fit the data. Some of these considerations are discussed below.

A short record of flood flows may contain large sampling errors because of chance geographical or temporal variations in rainfall during the period of record. Therefore a short record may be a poor indicator of the basic long-time distribution of floods at the site.

Flood flow frequencies often need to be determined for sites where there are no streamflow data. It is possible to examine the individual flood records within the region as a unit and to develop generalized relationships that apply anywhere in the region including ungaged sites. This approach often overcomes many of the uncertainties due to sampling error at individual sites. Several methods of regionalization have been developed to date; a study of such methods, and recommendations for their use, should be part of the continuing program of the Committee.

Another problem is the treatment of a record that contains one or more events of rare frequency - the so-called outlier problem. By using historical information at the site or at nearby sites it is often possible to assign a realistic recurrence interval to each outlier. This information is incorporated into the set of data to define the overall distribution. An alternative is to compute the frequency distribution omitting the rare events, plot the frequency line, and then to adjust the line to conform to the historical information. Where no historical information is available, an obviously very rare event may be excluded from the computations. The specific treatment that is used to handle outliers should become a matter of record.

Where streamflow data are lacking at the site or where a regional analysis is not justified, the use of hydrologic methods, such as rainfall-runoff relationships and unit hydrograph studies, may be the only feasible approach.

In the flood series for some streams in arid regions, it is not unusual for one or more of the flood values to be zero. This poses a difficulty when using a logarithmic transformation because the logarithm of zero is minus infinity. One way around the difficulty is to add a small constant to all the items of data. A second is to determine the frequency relation from only non-zero items and afterwards to adjust the relation to the full period of record. This methods does not retain the zeros.

A third method is to consider a two-step or conditional probability. If Z is the percentage of zero items, the frequency relation is based on the non-zero items, and defines the probability in 100 - Z percent of all years; Z percent of future years are considered as having expected values of zero. Or, for any one year, the expected probability of a zero flood is Z/100, and the expected probability of any other size of flood, given that the flood is not zero, is that furnished by the developed frequency relation. This may be thought of as a separation into two frequency relations, both solvable, which are then recombined.

The skew coefficient has greater variability between samples that the mean and standard deviation, and it is therefore a less reliable estimator of a population statistic for a particular site. Use of a regionalized skew coefficient to replace that coefficient computed from the station data has been recommended at times. The standard error of estimate of a sample skew coefficient Sg, taken from a normal population having zero skew, is given by:

$$Sg = \sqrt{\frac{6N(N-1)}{(N-2)(N+1)(N+3)}}$$

where N is the number of years of record. For a selected confidence level, this can be used to test whether or not a skew coefficient computed at a site is significantly different from zero. If a regional average skew coefficient is considered appropriate, the average of the Sg's, divided by $\sqrt{n}$, where n is the equivalent number of independent stations, should be used to test whether the regional value is significantly different from zero.

In the use of the log-normal and log-Pearson Type III distributions, an adjustment for length of record, referred to as "expected probability", have been applied to the probabilities. On the basis of comparative studies, it appears that the average fit of the log-Pearson is slightly improved by the use of this adjustment. However, the adjustment has been developed theoretically only for a normal (and log-normal) distribution, and its use for a log-Pearson Type III distribution is arbitrary. Simulation (Monte Carlo) techniques could be used to develop similar correction factors for the log-Pearson Type III distribution.

CCMS No. 2

PROPOSED
FLOOD HAZARD EVALUATION GUIDELINES FOR FEDERAL EXECUTIVE AGENCIES

by the Water Resources Council, United States

INTRODUCTION

Executive Order 11296 requires that the flood hazard be evaluated by all Federal executive agencies in planning of land use or of new Federal facilities, in modifying existing Federal facilities or in constructing new ones, in disposing of Federal lands or properties, and in administering facility construction programs supported by Federal grants, loans, or mortage insurance. The objective is to reduce the risk of flood losses by encouraging a broad effort to "preclue the uneconomic, hazardous, or unnecessary use of flood plains" along streams and coastal areas.

The present upward trend of average annual flood losses in the Nation may be modified downward if flood plain management and occupancy decisions more effectively take the flood hazard into account. The 1968 National Assessment of the Nation's water resources, prepared by the Water Resources Council, indicates that without such action the average annual national flood losses by the year 2000 could be as high as 3½ billion dollars, of which 60% would be in upstream reaches and 40% in downstream reaches. Losses that can be prevented will amount to a significant national economic gain; thus, there is a considerable incentive for making the Executive Order fully effective through all possible channels of action.

Objective

The objective of the Guidelines is to present applicable guides, standards, and criteria for the use of Federal agencies in implementing EO 11296, with a view to attaining general uniformity in the respective approaches.

The Guidelines are not intended to restrict Federal action in the furnishing of emergency disaster assistance. It is in Federal programs for assisting in replacement and reconstruction that there is opportunity for curtailing the uneconomic use of disaster relief funds in hazard areas.

The Evaluation of Flood Hazard

Throughout this document, flood hazard is used as a general term meaning not only the hazard occurring in river valleys and waterways when floods occur but also the hazard from extraordinary waves or high tides occurring on lake, estuary, or ocean shores, from the water or mud flows on hillsides and mountain slopes, from the flood flows in intermittent or normally dry streams, from floods on secondary streams or as a result of accumulated debris or ice, and from other similar occurrences.

Evaluation of the flood hazard in a flood-prone area must be based on factual or deduced information. Factual information is of three types: (1) Physical data that can be obtained at any convenient time, such as a stream bed profile, valley cross section, elevations at an existing facility, etc., (2) flood data that are available during or after a flood, such as flood depths and profiles, and the amount of damage suffered, etc., and (3) statistical data that can be obtained only over a long period of time, such as a statistical array of flood discharges and elevations in the area. If flood data and statistical arrays for a flood-prone area are not available, records within a wide region of hydrologically similar characteristics may be used to develop regionally applicable flood relations. Deduced information is that which can be inferred from factual information, such as the potential damage to an existing facility that has not yet suffered from flooding, the expected effects of anticipated upstream works of control, etc.

From this factual and deduced information the extent and frequency of flooding, or the risk (chance of occurrence), can be determined and applied in economic analysis of potential flood damage. The suddenness of inundation (the rate of flood rise), the duration of inundation, and other flood characteristics are important in determining flood hazard, but the decision on how the flood plain lands can be properly used requires analysis of many other factors such as the possibility of loss of life, interruption of services, nuisance cost, and other consequences of flooding.

The amount and quality of information required for flood hazard evaluation will vary with the degree of risk, economic considerations, and other anticipated consequences of flooding. Usually the depth of flood water in a flood-prone area is the most significant factor in the amount of damage done by flooding. However, water quality, flood velocity, scour, sediment deposition, debris, floating ice, adequate flood warning and opportunity to evacuate persons and goods or equipment, the rate of flood rise, and the duration of flooding may also be significant factors.

Potential or actual flood damages are generally estimated for two categories - tangible and intangible - for various depths of inundation. The tangible damages are those to buildings and their contents, vehicles, streets and roads, utilities, the soil resource, forest, forage, and agricultural crops, recreational facilities, fish hatcheries, and many other commodities, which can be readily determined in dollar terms for the current situation or land use. The amount of damage at a given flood elevation varies with the present and potential land use and type of property. For the latter, the damage may vary within types, on the methods and materials used in construction, and on the contents. Damages to land consist of loss of land by erosion, slides, and similar occurrences; loss of crops, cover, and plantings; and loss of the use of the land. Damages to property consist of loss of physical structures and their use, loss of goods and their services, and loss of the potential for producing goods and services. Costs of cleanup, repair or replacement, and the cost of flood fighting or emergency action are tangible private and public losses. Intangible damages, which are sometimes very difficult to evaluate in dollar terms, include loss of life, human anguish, inconveniences, damage to wildlife, and damage to environment.

GUIDELINES

These Guidelines are concerned with the evaluation of flood hazard for the purposes of Section 1 and 2 of Executive Order 11296, with related subjects having some bearing on the implementation of Sections 3 and 4, and with assistance in implementing Section 6. Methods or procedures mentioned in the Guidelines either are given in appendices of this document or are available from sources of flood hazard information mentioned in Section 3 of the Executive Order. In some cases of applications it may not be necessary to consider every Guideline; in others, the order in which the Guidelines are followed may be advantageously modified.

In carrying out their responsibilities under Executive Order 11296, Federal executive agencies should:

(1) determine first whether there is a need for considering the flood hazard at the site or structure in question. Essentially, this means making a decision on whether the site or structure is in a flood plain (riverine, coastal, or other). Flood plain, as referred to herein, is the area, usually a relatively flat or lowland area,

adjoining a river, stream, watercourse, ocean, bay or lake, which in the past has been covered temporarily under extreme flood conditions or can be reasonably expected to be so covered in the future. The concerned agency can either make a brief preliminary investigation or request the information from the sources mentioned in Section 3, EO 11296. If it is concluded by the concerned agency that there is a need to consider the flood hazard, then the remaining provisions of the Guidelines will apply as appropriate;

(2) adopt a study framework in which the hazards are described in terms of the 25-, 50-, and 100-year frequency floods and of the substantially larger flood (the flood-plain flood) which, when it occurs, covers the entire flood plain;

(3) adopt as a working principle the need for defining a floodway, free of significant flow obstructions, when the limits of one have not yet been established in a flood-prone area, and for keeping established floodways obstruction free. Floodway, as referred to herein, is that section of a flood-prone area provided for accommodating the passage of a 100-year riverine or coastal flood, so that remaining sections of the area can be more economically employed;

(4) determine whether there are existing laws or statutes of the Federal Government, rules or regulations of Federal agencies, or statutes, ordinances etc. of State or local government that provide standards for management of the flood-prone area in question. In cases where those standards are either more stringent than those based on these Guidelines, or applicable to situations or conditions not covered in these Guidelines, they shall be adopted for the evaluation of flood hazard in that area;

(5) decide whether to make the hazard evaluation by means of a thorough investigaton of benefits and costs (including those of the affected vicinity) resulting from use of the site or structure, or by means of a procedure comparable with that given in Appendix 2 of this guideline document;

(6) permit a potential developer of Federal lands or properties that are to be disposed of by the Federal Government to submit a report of a thorough investigation of benefits and costs (including those of the affected vicinity) in support of a claim that such lands or properties are suitable

for economic development by him. The Federal agency disposing of those lands or properties shall review the benefit cost investigation, or have the review made at cost by one of the agencies mentioned in Section 3, EO 11296, and shall accept or disallow the claim according to the Federal Government's findings in the matter;

(7) use the 100-year frequency (1-percent chance, or 100-year recurrence interval) flood as the design flood for determination of required floodway size or capacity. For a location where a flood frequency analysis is not already available, the flood frequencies shall be determined by the procedure approved and adopted by the Water Resources Council and given in the Council's Bulletin 15, "A Uniform Technique For Determining Flood Flow Frequencies". For a location where a flood frequency analysis is already available and the analysis gives results consistent with results from the Council's procedure, that analysis may be adopted for use in that location;

(8) use, as the minimum amount of information for the evaluation of flood potential, the elevation of the lowest point of water entry (taking seepage into account, if necessary) at the site or structure, and the elevations of the 25-, 50-, and 100-year frequency floods and the flood-plain flood, at the location nearest the site or structure, assuming a designated floodway in place;

(9) obtain information on whether the proposed site or structure is located within the area of an actual or potential designated floodway, or outside the floodway but within the flood plain, or outside the flood plain;

(10) obtain information on the proposed use of the site or structure, proposed human or animal occupancy, and proposed facilities and their contents;

(11) obtain information, when applicable, on the present and proposed means of occupant warning and evacuation to be used before and during floods in the area;

(12) obtain information, when applicable, on the effects of proposed upstream or local flood prevention or control measures, if any that will modify the elevation of the 100-year flood assuming it to be confined within an actual or potential designated floodway. The primary sources of this information are the agencies mentioned in Section 3, EO 11296;

(13) evaluate flood hazard at the site or structure either by use of the information from the thorough investigation of benefits and costs, if that approach was adopted, or by use of a procedure equivalent to that given in Appendix 2 of this guidelines document;

(14) modify the evaluation of Guideline 13 by taking into account the information in Guidelines 8, 9, 10, 11 and 12, whichever are applicable, and by taking into account other pertinent information about the area such as the probability of mud or rock slides, ice jams, or flooding from secondary streams;

(15) modify the evaluation of Guideline 13 by taking into account the potential for increased flood hazard that may result from the proposed development's encouraging further development not financed with Federal funds, or Federally sponsored, and located within the high damage area (floodway);

(16) adopt the policy of discouraging the construction of roads and public utilities within the area of an acutal or potential designated floodway, in order to preclude damage-prone uncontrollable or undesirable developments in the floodway;

(17) make an initial decision on whether the proposed use of the site or structure is permissible on the basis of the actions taken regarding Guidelines 14, 15 and 16;

(18) modify the decision of Guideline 17 if flood proofing of a permanent nature, or other permanent protection, will reduce the flood hazard to a suitable level at the proposed development and if neither the protection nor the development will be significant obstructions to flow in the actual or potential designated floodway;

(19) develop, for sites or structures to be protected in the future by upstream or local flood prevention

or control measures, a schedule of permitted construction of facilities and of human occupancy of the site or structure to ensure that construction or occupancy do not occur before the measures are effective;

(20) delineate, or ensure the delineation of, on Federally owned properties, the evaluation of the 100-year flood (for future conditions of the flood-prone area) at the site or structure if the site or structure has any elevation below that of the 100-year flood. Also delineate elevations of other floods of record at that location, whose occurrences should be made known to the public;

(21) keep a permanent record of information on the specific flood-prone area or site or structure, the flood hazard evaluation procedure and classification, the flood prevention or control measures proposed for upstream or local construction, the permitted construction of facilities, the permitted human occupancy, the guarantees from developers whose permission to build or occupy is contingent on their performance of specified actions, the flood elevation delineations, the decisions reached for the area, and the schedule for construction and occupancy. It is not necessary, but may be desirable, for the total record to be kept on file by the agency most concerned about the area;

(22) develop procedures, regulations, and information, as directed in Section 6 of the Executive Order, using these Guidelines as a basis. Achieve a general uniformity with the respective approaches of other Federal executive agencies by referring the procedures and regulations to the Water Resources Council for review and comment.

APPENDIX 1

EXECUTIVE ORDER 11296

Executive Order 11296 is reproduced here in its entirety from the Federal Register, Vol. 31, No. 115, pp 10663-4 - Thursday, August 11th, 1966:

Title 3 - THE PRESIDENT

Executive Order 11296

Evaluation of Flood Hazard in Locating Federally Owned or Financed Buildings, Roads, and Other Facilities, and in Disposing of Federal Lands and Properties

WHEREAS uneconomic uses of the Nation's flood plains are occurring and potential flood losses are increasing despite substantial efforts to control floods; and

WHEREAS national and regional studies of areas and property subject to flooding indicate a further increase in flood damage potential and flood losses, even with continuing investment in flood protection structures; and

WHEREAS the Federal Government has extensive and continuing programs for the construction of buildings, roads, and other facilities and annually disposes of thousands of acrea of Federal lands in flood hazard areas, all of which activities significantly influence patterns of commercial, residential, and industrial development; and

WHEREAS the availability of Federal loans and mortgage insurance and land use planning programs are determining factors in the utilisation of lands:

NOW, THEREFORE, by virtue of the authority vested in me as President of the United States, it is hereby ordered as follows:

SECTION 1. The heads of the executive agencies shall provide leadership in encouraging a broad and unified effort to prevent uneconomic uses and development of the Nation's flood plains and, in particular, to lessen the risk of flood losses in connection with Federal lands and installations and Federally financed or supported improvements. Specifically:

(1) All executive agencies directly responsible for the construction of Federal buildings, structures, roads, or other facilities shall evaluate flood hazards when planning

the location of new facilities and, as far as practicable, shall preclude the uneconomic, hazardous or unnecessary use of flood plains in connection with such facilities. With respect to existing Federally owned properties which have suffered flood damage or which may be subject thereto, the responsible agency head shall require conspicuous delineation of past and probable flood heights so as to assist in creating public awareness of and knowledge about flood hazards. Whenever practical and economically feasible, flood proofing measures shall be applied to existing facilities in order to reduce flood damage potential.

(2) All executive agencies responsible for the administration of Federal grant, loan, or mortgage insurance programs involving the construction of buildings, structures, roads or other facilities shall evaluate flood hazards in connection with such facilities and, in order to minimize the exposure of facilities to potential flood damage and the need for future Federal expenditures for flood protection and flood disaster relief, shall, as far as practicable, preclude the uneconomic, hazardous, or unnecessary use of flood plains in such connection.

(3) All executive agencies responsible for the disposal of Federal lands or properties shall evaluate flood hazards in connection with lands or properties proposed for disposal to non-Federal public instrumentalities or private interests and, as may be desirable in order to minimize future Federal expenditures for flood protection and flood disaster relief and as for as practicable, shall attach appropriate restrictions with respect to uses of the lands or properties by the purchaser and his successors and may withhold such lands or properties from disposal. In carrying out this paragraph, each executive agency may make appropriate allowance for any estimated loss in sales price resulting from the incorporation of use restrictions in the disposal documents.

(4) All executive agencies responsible for programs which entail land use planning shall take flood hazards into account when evaluating plans and shall encourage land use appropriate to the degree of hazard involved.

SECTION 2 As may be permitted by law, the head of each executive agency shall issue appropriate rules and regulations to govern the carrying out of the provisions of Section 1 of this order by his agency.

Section 3 Requests for flood hazard information may be addressed to the Secretary of the Army or, in the case of lands lying in the basin of the Tennessee River, to the Tennessee Valley Authority. The Secretary of the Tennessee alley Authority shall provide such information as may be available, including requested guidance on flood proofing. The Department of Agriculture, Department of the Interior, Department of Commerce, Department of Housing and Urban Development, and Office of Emergency Planning, and any other executive agency which may have information and data relating to floods shall co-operate with the Secretary of the Army in providing such information and in developing procedures to process information requests.

SECTION 4 Any requests for appropriations for Federal construction of new buildings, structures, roads, or other facilities transmitted to the Bureau of the Budget by an executive agency shall be accompanied by a statement by the head of the agency on the findings of his agency's evaluation and consideration of flood hazards in the development of such requests.

SECTION 5 As used in this order, the term "executive agency" includes any department, establishment, corporation, or other organizational entity of the executive branch of the Government.

SECTION 6 The executive agencies shall proceed immediately to develop such procedures, regulations, and information as are provided for in, or may be necessary to carry out, the provisions of Sections 1, 2, and 3 of this order. In other respects this order shall take effect on January 1, 1967.

LYNDON B. JOHNSON

THE WHITE HOUSE,
August 1, 1966

(F.R. Doc. 66-8838; Filed, Aug. 10, 1966; 12:14 p.m.)

APPENDIX 2

A GENERAL PROCEDURE FOR EVALUATING FLOOD HAZARD

The procedure mentioned in Guideline 5, as an alternative to a thorough investigation of benefits and costs, is presented in this appendix. Examples of its use are given in Appendix 3. The remaining appendices describe some technical methods useful in various steps of the procedure.

If the use of the procedure produces an evaluation that appears unsatisfactory, then the obvious course is to make a thorough investigation of the flood hazard by a benefit-cost analysis.

Basic Approach

For a large class of flood evaluation problems, experience has shown that it is simplest and most appropriate to work with types of facilities rather than with the total economic problem, and to modify the result by more detailed analysis when it is necessary to account for special circumstances. That is the approach of this procedure.

Evaluation Procedure

The evaluation procedure consists of a series of statements, each concerned with a progressive unit of work (not necessarily of the same importance or magnitude) and each accompanied by suggestions for accomplishing this work. In an application of the procedure, several steps can be completed at the same time or taken in a different order if it is feasible. For some evaluations, only a few of the steps may be needed. Where it is appropriate in a step, there is a reference to the applicable Guideline.

It is assumed that the concerned agency has decided that a flood hazard evaluation is needed (Guideline 1); also, that the concerned agency's decision (Guideline 5) has been for use of this procedure. If more stringent standards are applicable (Guideline 4), then the overall procedure is to be modified as necessary. The procedural steps follow:

1. Learn the geographical location of the site or structure for which the flood hazard evaluation is to be made, and the location with respect to the flood source. Identify the nature of the flood hazard, whether it is from river rise, lake waves, ocean tides, ramming action of debris, etc., and, if readily possible, the contributing cause of the flood hazard, whether because of excess precipitation, poor hydrologic condition of the watershed,

debris slides and accumulations, snow avalanches, bridge or culvert or other channel obstructions, ice accumulations, etc. Determine the location and nature of proposed upstream or local works of improvement that may affect the flood hazard.

2. Learn whether a designated floodway exists at the location (Guideline 3). If one does exist, obtain the physical limits of the floodway assuming it to be flowing full. This information may be available locally in offices of the State, county, or city, or of a flood control district; if it is not, then the agency concerned must either develop the information itself or obtain it from one of the sources mentioned in Section 3, EO 11296.

3. Obtain flood frequency data and make an analysis for the flooding at the site or structure (Guideline 7). Technical guidance is found in the Council's Bulletin 15. If there are no flood data for the location, then a basin or regional analysis is needed. For many areas such analyses are already made and are available from the sources mentioned in Section 3, EO 11296. If not, then the analysis is made by the concerned agency or requested from a source agency.

4. Determine the 10-, 25-, 50-, and 100-year flood frequency magnitudes from the analysis of step 3. The 10-year value is used indirectly in the evaluation (see Step 6).

5. Determine the water surface elevations of the 10-, 25-, 50-, 100-year and the flood plain floods. Flood discharge elevations may be available for a gaging station at the location or from locally recorded high water marks. If such elevations are for stations too distant to be directly applicable, then a backwater or other hydraulic computation will be necessary to develop flood profiles or otherwise to project the flood elevations to the site or structure under study. If the frequency analysis was requested from a source mentioned in Section 3, EO 11296, then that source may also be able to supply the needed elevations; if not, then the agency concerned must determine them itself.

6. Make adjustments in elevations of the 25-, 50-, and 100-year flood frequency elevations for uniformity of economic loss, using the adjustment factors of Appendix 6, if such adjustments are appropriate.

7. Make or have made a topographic cross section through the site or structure area and the local flooding source (river, etc.), either by field survey or by use of an existing contour map for the site or structure area and vicinity. Such a section is useful in determining flood elevations (Step 5), making adjustments for economic loss (Step 6), determining the

limits of a floodway, or determining the inundation limits of floods. A source agency (Sec. 3, EO 11296) that supplies flood magnitudes or elevations may be able to supply the cross section also; if not, the concerned agency must develop it.

8. Determine the lowest elevation at which either flooding begins at the site or structure or water enters the structure. This can be obtained through use of a topographic cross section from a source agency (Sec. 3, EO 11296) or determined in the field.

9. Check whether the existing floodway, if any, has a flow capacity equal to or greater than the magnitude of the 100-year flood. If so, the existing floodway information is used in the evaluation. If not, the dimensions of a floodway with the proper capacity are determined.

10. Determine the location and dimensions for a floodway if one does not exist at the location.

11. Obtain information on the type of existing or proposed development at the site or the use of the structure. This information ordinarily will be an indicator of human occupancy, facility contents, etc., but not of escape avenues during flooding or of available flood warning systems, etc. The forms given in Appendix 7 indicate the kind of information that can be of value if it is available. Of special interest is the possibility of facility damage by seepage, erosion, or buoyance, and potential damage from storage of materials that are buoyant, flammable, explosive, or otherwise injurious to human, animal, or plant life.

12. Enter Table 1 with the information of Step 11 and determine the level of protection needed, as a minimum, for the site or structure, using the table as a guide. The site evaluation chart is helpful in this step when details of facilities and contents for a specific case are not covered in Table 1.

13. Determine from the site or structure location (Step 1 or 7), from the minimum water entry elevation (Step 5), whether the site or structure has the minimum level of protection found in Step 12. If it has, then Step 14 is applicable next. If it has not, then either the proposal for establishment or use of the site or structure is not acceptable or further means of reducing flood hazard must be sought, as described in Step 15.

14. Determine for the site or structure having adequate protection, as found in Step 14, whether there are other hazards in the immediate vicinity that would void the protection classification. These other hazards may be ice jams in a river, accumulations of shore ice through action of wind or waves, flows with large-sized debris, flooding from a secondary stream, flooding from a ditch or drain, snowslides, landslides caused by infiltration of rain or snowmelt, backwater from downstream or local stream junctions, impoundments, bridges, culverts, debris accumulations, or other obstructions, flooding from insufficient drainage, inaccessibility during flood rises, or other similar events. If such an additional hazard exists, the proposal for establishment or use of the site or structure is not acceptable unless some permanent means of eliminating the hazard is used as part of the establishment or use.

15. Determine for the site or structure having a higher risk than desirable, as found in Steps 13 or 14, whether protection or permanent flood proofing can be installed to decrease the flood hazard to a satisfactory level. If it can, the proposal for establishment or use of the site or structure is acceptable, contingent on the installation of the appropriate protection or flood proofing.

16. Make the terminal decision on either accepting or rejecting the proposed establishment or use of site or structure, on the basis of the preceding steps.

Table 1.- A guide for determining the minimum desirable level of protection from flood hazard, using facilities or their contents as the indicator of potential damage.

Minimum level of protection	Facilities or contents
Class 1: Lowest water-entry elevation of the facility is outside the flood plain.	Buildings containing valuable historical, legal, medical, financial, governmental, literary, or scientific documents or data.
	Buildings containing research, commercial, or industrial instruments or machinery of high value or which contain materials whose escape or damage through flooding would endanger the public.
	Hospitals and other buildings containing persons incapable of leaving during flooding and who may be endangered by failure of building utilities or services.
	Buildings in themselves of national value.
	Buildings of diplomatic importance.
	Power installations needed during emergencies.
	Warehouses, stock piles, tanks, and other facilities storing materials dangerous to the public if affected or released by flooding.
Class 2: Lowest water-entry elevation of the facility is not below the elevation of the adjusted 100-year flood.	Homes, apartment buildings, hotels, motels, and other residential buildings whose occupants may not have adequate warning or means of escape during floods.
	Educational institutions, including dormitories.

Class 2, continued

Health institutions, including clinics, DDS and MD offices, and veterinary establishments.

Airfields or airports needing a high degree of protection.

Communications buildings, including telephone exchanges, telegraph offices, radio and TV stations.

Camp grounds for family groups or youth organisations.

Public service buildings such as police and fire stations.

Commercial and industrial buildings containing moderate cost or replaceable equipment or machinery.

Entertainment buildings such as stage or movie theaters, concert halls, and auditoriums.

Precision workers' shops such as those of engravers, jewelers, and machinists.

Public utility buildings or installations such as water or gas works.

Buildings in which animals are housed and from which they cannot escape during floods.

Warehouses, stock piles, tanks, and other facilities storing non-dangerous materials of public value.

Class 3: Lowest water-entry elevation of the facility is not below the elevation of the adjusted 50-year flood and is outside the designated floodway.

Shops or stores retailing consumer goods of no more than moderate value.

Airfields or airports needing only a moderate level of protection.

Class 3, continued	Commercial and industrial buildings containing equipment or materials not dangerous to the public if flooded and not of high value. Commercial service shops with salvageable equipment or goods. Buildings or sheds for storage of easily moved machinery or vehicles. High value agricultural or horticultural fields.
Class 4: Lowest water-entry elevation of the facility is not below the elevation of the adjusted 25-year flood and is outside the designated floodway.	Open-air markets, amusement parks, or theaters. Warehouses, stock piles, tanks, and other facilities storing non-dangerous low-cost or recoverable equipment or materials.
Class 5: Lowest water-entry elevation of the facility is at any elevation above that where flooding begins in the flood plain.	Farm fields, pastures, and other open-air agriculturally used lands. Parks, picnic grounds, and other open-air public spaces. Vendors' stands in parks.

Further appendices are summarized below. The full text can be obtained from the Water Resources Council, 1025 Vermond Avenue NW, Washington DC 20005.

APPENDIX 3 gives examples of the use of the evaluation procedure.

APPENDIX 4 presents a flood hazard classification system which differs in several respects from that of table 1 in Appendix 2. In this second system, a site evaluation chart is used to form a judgment on the merits of a proposed or existing site in relation to flood hazard.

APPENDIX 5 is concerned with the two boundary floodway problem. In Guideline 3, a floodway is defined as "... that section of a flood prone area provided for accommodating the passage of a 100-year riverine or coastal flood, so that remaining sections of the area can be more economically employed." For a riverine area, the floodway has two boundaries, which are determined by successive approximation of interpolation.

APPENDIX 6 describes a procedure for approximating a uniformity of economic loss when using a flood hazard evaluation procedure, such as that of Appendix 2, that does not specifically deal with economic loss magnitudes.

APPENDIX 7 suggests flood hazard information forms, which may be useful in evaluating flood hazards as is mentioned in Step 11 of the procedure in Appendix 2.

INTRODUCTION TO FLOOD PROOFING
- AN OUTLINE OF PRINCIPLES AND METHODS

BY J. SHEAFFER (UNITED STATES)

Chapter I
The Uses and Limitations of Flood Proofing

Flood proofing consists of those adjustments to structures and building contents which are designed or adapted primarily to reduce flood damages. Such adjustments can be scheduled to be undertaken in existing buildings during periods of remodelling or expansion. Also, they can be incorporated into new buildings during initial construction at locations where studies have shown that such buildings would constitute a proper use of a flood plain.

Flood proofing, like other methods of preventing flood damages, has limitations. It can generate a false sense of security and discourage the development of needed flood control or other actions. Indiscriminately used, it can tend to increase the uneconomical use of flood plains. Applied to structurally inadequate buildings, it can result in more damage than would occur if the building were not flood proofed.

The flood proofing technique also presents certain practical difficulties. A complex pattern of land and building ownership would present problems in co-operation before a community-wide program of flood proofing could be carried out. In addition, retail businesses as well as houses frequently change ownership and this tendency would discourage investments for producing primarily long term flood protection benefits. Another complication is the requirement of accurate and timely flood forecasts for successful flood proofing operations in some areas.

The Values of Flood Proofing

Flood proofing has important values when treated as part of a broader program for comprehensive flood plain management. Continued occupance of developed flood plain sites, may become necessary in some low lying areas - - especially in certain urban areas where a shortage of land may offer no alternative.

In addition to its principal values of permitting occupance in flood plains and enabling a building to function during flood periods, flood proofing has some other benefits:

1. It offers an additional tool in a comprehensive flood damage reduction program.

2. It can increase the protection afforded by partial protection flood control projects.

3. It may improve the availability of flood insurance.

4. Properly understood, it can increase interest in flood damage reduction programs by heightening the awareness of flood risk.

Flood proofing is not a cure for all flood problems. Rather, it should be considered as one device among an array of available flood damage reduction measures, including land use regulation and change, flood control projects, flood fighting, flood relief, and flood insurance. A comprehensive flood plain management program would probably involve the use of several or all of these techniques.

When is Flood Proofing Appropriate?

The characteristics of flooding vary from flood plain to flood plain and the type of development on flood plains is highly diverse. This variation makes it difficult to select the flood damage reduction instruments best suited to a given flood plain situation unless a detailed analysis is undertaken. The appropriateness of flood proofing in any given region depends upon the stage of flooding, the velocity of flow, the duration of the flood period, the uses being made of the flood plain, and the relationship of flood proofing to other flood damage reduction measures.

A flood proofing program would normally warrant serious consideration as a means of flood damage reduction in the following circumstances:

> Where studies have concluded that it is not economically feasible to provide flood control structures, flood proofing could provide a substitute means of reducing flood losses.
>
> Where authorized flood control projects have not been constructed because of lack of local co-operation, flood proofing could provide property owners with an opportunity to reduce their flood risk.

Where utilities, manufacturing plants, and navigation terminals require reiverfront locations to function effectively, flood proofing could provide the owners of these facilities an opportunity to achieve a degree of flood damage reduction. The highest practicable level of protection should be afforded to assure continuation of utilities.

Where flood proofing and flood insurance are closely allied, a property owner could elect to flood proof to reduce his flood risk in order to obtain more favorable flood insurance rates.

Where flood control projects have provided only partial flood protection, flood proofing could enable property owners to achieve a higher degree of protection than would otherwise be provided.

In actual cases where buildings have been flood proofed in accordance with plans developed with professional engineering and architectural assistance, flood proofing has performed satisfactorily and has mitigated flood losses. A number of examples will be cited in later chapters.

Flood Proofing and Flood Control

Flood control measures, such as reservoirs, levees, channel improvements, and watershed treatment, seek to keep flood water within established channel banks or floodway limits. Flood proofing seeks to reduce damage once the water reaches a building. Although in most instances the benefits of flood control will exceed the costs, there are many communities, where flood control measures are not economically justified. In such communities the flood proofing of individual structures could result in a substantial reduction in flood losses.

In other communities, where flood control projects are economically justified, as many as 20 years have elapsed between authorization and actual construction of an approved project. In such situations, flood proofing could be undertaken as an interim flood damage reduction measure for selected buildings, and either discontinued with the construction of the flood control project or used in some cases to attain an additional degree of protection than that provided by the flood control project.

Flood Proofing and Flood Plain Regulations

To help bring about the economic use of flood plains, states, counties and municipalities frequently adopt comprehensive flood plain regulations. These regulations may be incorporated in building codes. Subdivision regulations, or zoning ordinances. Since the emphasis is on promoting proper use, rather than on prohibiting use, flood proofing can be a useful element in flood plain regulations.

When studies show parts of a flood plain to be potentially suited for more intensive use, flood proofing would allow development in these hazardous areas. Because of the adjustments made, however, the potential flood damages are reduced and the pressures for a public flood control project are likewise reduced. From this vantage point, flood proofing techniques are important, not only to individual property owners, but to public officials interested in proper flood plain management.

A flood control approach now being considered is to clear the flood plain through a system of tax rebates which reduce a property value to zero over a 10 or 20 year period. In such an approach, flood proofing could furnish protection to a building during the amortization period prior to its demolition.

Flood Proofing and Flood Insurance

Flood proofing and flood insurance are interrelated and can be considered together in a comprehensive program for flood damage reduction. Effective flood proofing could be used to reduce flood risks to a level where it would be possible for private insurance firms to underwrite flood insurance at a marketable rate. This is the situation in the Golden Triangle of Pittsburgh, where flood insurance on a private commercial basis is available to the J.P. Horne Company because of their flood proofing program.

Flood proofing is used to protect against the losses that would otherwise occur from the more frequent flood events, while flood insurance is used to protect against losses from the less frequent event -- the large magnitude flood which occurs so infrequently and has such a high stage that it is not economically feasible to flood proof against it.

If flood insurance becomes more widely available, the effect should be to stimulate flood proofing, since the insuring companies would encourage protection of the insured properties and would reward such protection with reduced flood insurance rates. In a federally sponsored flood insurance program, for example, the premium schedule would probably reflect degrees of flood risk. A flood proofed building able to withstand a flood stage that was considered a low risk would most certainly obtain a more desirable premium rate. The potential dollar savings in premiums could serve to encourage property owners to use flood proofing measures.

Flood Proofing Decisions

The protection of property from flood losses depends, in part, upon the owner's awareness of the flood hazard and a willingness to do something about it. To arrive at feasible decisions pertaining to flood proofing, the property owner must recognize potential flood problems and their related effects. This knowledge can be obtained in several ways.

The worst way, of course, is personal experience — to have seen one's own building damaged and its contents ruined and to have suffered the labor and cost of cleaning up. There are other ways, however.

A building owner may become aware of a flood hazard from a "near miss" when a flood almost caused a catastrophe. If flooding occurred before the present owner located on the site, he may have been informed by others that the property he now occupies had been severely damaged in the past.

The owner may have been unaware of his flood exposure, until he heard of reports which outlined flood problems, (1) or saw maps showing areas subject to flooding. The flooding problem may have been called to the owner's attention by public officials when they embarked upon a program of flood plain management by adopting building, subdivision, and zoning ordinances which included controls over developments in flood plains.

Information on the flood hazard may come from any of these sources, but the determination of the stage of protection and the formulation of a course of action to reduce losses is complex and would require professional assistance.

If a property owner decides to explore the possibilities of flood proofing, he should seek the help of professionals who have a working knowledge of structures and who have had experience in flood proofing. An examination of the building should be made by qualified professional engineering and architectural personnel. The structural soundness of foundation conditions.

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(1) Such information has been made available for many areas in flood plain information reports of the Corps of Engineers, local flood reports of the Tennessee Valley Authority, and Hydrologic Atlas Maps of the United States Geological Survey.

A building owner will naturally want to measure an expenditure of money for flood proofing against the protection he receives. For this purpose he should make it a point to include a benefit-cost analysis as part of his inquiry. This involves determining the dollar extent of the flood hazard by first calculating the probability of floods of various levels at the site and then estimating the damage to the particular building from those levels of flooding. The result is an estimate of dollar loss from flooding which is considered as the flood proofing benefit -- that is, the amount saved by flood proofing to various levels of protection. This benefit is then matched against the cost of cost proofing on an average annual basis to produce a benefit-cost ratio. A fuller evaluation of flood proofing is presented in a previous report entitled Flood Proofing: An element in a Flood Damage Reduction Programme. (1)

Professional hydrological advice, from such agencies as the United States Army Corps of Engineers or the Tennessee Valley Authority, is available in calculating the general flood hazard at a site. Estimating the probable damage from various flood levels is usually done best by the building owner himself, in consultation with a professional engineer or architect. The same professional can then estimate the cost of flood proofing over a prescribed time period.

The decision to flood proof, or not, rests finally with the building or property owner. A decision against altering the building, for whatever reason, need not necessarily mean a total discard of all flood proofing techniques. A plan of action as simple as the water proofing of machinery, the disconnection or raising of electrical circuits, etc., or a plan for the orderly removal of machines or merchandise, may be the only logical recourse in some circumstances; but even these measures will reduce flood losses, sometimes substantially. Another approach would be to permanently reorganize the use of space in the building.

Flood proofing measures that are temporary safeguards require advance preparation, as do more complicated programs, and plans should be developed for their implementation. Any step which is carried out primarily to reduce the probability of damage is an ingredient in a flood proofing program.

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(1) John R. Sheaffer, Flood Proofing: An Element in a Flood Damage Reduction Program, Department of Geography, Research Paper 65, University of Chicago (Chicago: by the Author, 1960), pp. 27-42

Chapter II
The Physical Environment and Types of Flood Proofing

Buildings on flood plains can be damaged by seepage of flood waters through walls and foundations by ground-water pressure on floor slabs and walls, by the backup of water through sewerage systems, by the entrance of flood waters which overtop channel banks and inundate flood plains, and by ice jams. The physical environment is an important factor in determining which sources of flood waters are present at a particular location, and thus will influence the nature and design of flood proofing measures.

The permeability of the earth materials, the stability of flood plain slopes, and the interconnection of flooding with the ground water resource are significant environmental elements to be considered. Under some conditions these environmental elements could rule against the use of flood proofing, while in others the condition could promote the use of flood proofing.

Permeability of Site Materials

The permeability of the materials at a building site largely determines the movement of ground water around and under the foundation walls and floor slab. In some environments, ground-water pressure will build up against such buildings. In these situations a drainage system can be considered as a means to relieve the ground-water pressure by creating a cone of depression (pumping cone) under the building.

Permeability, in part, determines the level of the zone of saturation (commonly known as the water table). Beneath this level, problems of underground seepage control are most likely to be encountered. However, such problems can also be encountered above this level in areas which have localized "perched" water table conditions.

The range in permeability of some common types of earth material is presented in the following table. In materials of low permeability, such as clay, the quantity of ground water flow into underground openings is likely to be small even at relatively high gradients and could be drained only with a close network of tiles. In materials of high permeability, such as sand and gravel, the quantity of flow, even at relatively low gradients, may be so large, that it would be extremely difficult to prevent the level of ground water saturation from rising even with a drainage system.

TABLE 1: RANGE IN PERMEABILITY FOR SELECTED MATERIALS

Selected Materials	Range in Permeability
Unweathered clays	Low
Very fine sands, silts; mixtures of sand, silt, and clay; (Common Flood Plain Deposits)	Intermediate
Clean sands, mixtures of clean sands and gravels (Coarse textured alluvial fan, glacial outwash)	High
Clean gravel	Very High

Source: Based on Todd, Ground Water Hydrology (1959), p.53

The pressure exerted by ground water on structures is that of the upward and lateral hydrostatic pressures which are related to ground water levels. Buildings must have the structural strength to withstand these pressures or they must be relieved by drainage system. The feasibility of relieving pressure by drainage (pumpage) is a function of the permeability. Many of the common flood plain deposits fall within the intermediate range of permeability and are susceptible to pressure release by pumped drainage. However, many flood plains are layered and have widely varying permeability.

At locations where landslides or land slumping are prevalent, it appears that flood proofing would not be appropriate. Rather, effort should be directed to restricting the development of such areas and clearing them of existing potentially dangerous structures.

Flood Forecasting

Reliable, accurate and timely forecasts of flooding and flood stages are a prerequisite for a flood proofing program. The main stems of the major river valleys are generally provided with efficient flood forecasting services. However, many urban areas are not now provided with such services. It may be possible to provide these services in the future if staff, equipment and data are expanded. In the light of this shortcoming, the Bureau of the Budget's Task Force on Federal Flood Control Policy has recommended that an improved system of flood forecasting should be developed by the Environmental Science Services Administration as part of a disaster warning service. As flood forecasts become more widely available, the feasibility of using flood proofing as a means of flood damage reduction is also broadened.

Types of Flood Proofing Measures

Flood proofing measures can be classified into three broad types. First, there are permanent measures which become an integral part of the structure and, in consequence, are rarely noticeable. Second, there are contingent or standby measures which are used only during floods, but which are constructed or made ready prior to any flood threat. Third, there are emergency measures which are carried out during a flood according to a predetermined plan.

Permanent Flood Proofing Measures - These measures essentially involve either the elimination of openings through which water can enter or the reorganization of spaces within buildings. In some instances, they yield multiple benefits. Thus, a watertight flood shield (1) at a doorway opening can also serve as the door. A raised terrace and gently sloping ramp that furnishes access over a low flood shield at the doorway of a store can also provide a view of the entire sales floor as one enters.

From the standpoint of readiness, permanent measures are preferable to any other, and should be incorporated into a flood proofing program to the greatest degree practicable. In many cases, permanent flood proofing does not require an advance flood warning of the availability of special personnel and it provides the greatest measure of safety by reducing the element of human error. Because of the possibility of unforseen failure, trained personnel should be on hand in the event of an emergency. At some buildings it may be possible to make many permanent changes while at others, few will be possible, if any.

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(1) A flood shield is a metal plate of aluminum or steel, a fabricated "gate", a wooden plank or any other device that is used to close off building openings to prevent the entry of flood water.

Contingent or Standby Measures - In many buildings it is necessary to maintain access into structures at points below selected flood protection levels. In addition, display windows at commercial structures must be unblocked to serve their main purpose. These types of openings cannot be permanently flood proofed, but they can be fitted with removable flood shields. The placement and installation of such devices, however, would require several hours. Therefore, a flood warning system would have to be established before such flood proofing measures could become operational.

Many contingent or standby flood proofing devices have relatively long periods of usefulness -- for example, the steel or aluminum flood shields. Building remodeling may alter an opening in such a way that its flood shield is no longer useful, however. In such cases, emergency sandbagging or other temporary measures may be needed. The outmoding of protective measures will be less likely if they are made a part of a building's superstructure and can retract into the ceiling above entrances.

Emergency measures - These are measures which are carried out during an actual flood experience. These measures may be designed to keep water out of buildings, for example, the sandbagging of entrances or the use of planking covered over with polythene sheeting. More often they are intended only to protect equipment and stock. A widely used emergency measure is the planned removal of contents to higher locations when a certain flood stage is reached.

Emergency measures have proven to be an effective means of reducing flood losses, particularly where flood warnings are issued several days in advance of the water's arrival. At times, emergency measures can include actual construction. In some cases the lower sections of windows and doors have been bricked shut in anticipation of flooding, on other occasions temporary walls and levees have been built to keep flood waters away from structures. In some instances where it was not possible to prevent the entry of flood waters, machinery has been dismantled and taken to sites above flood stages, and large quantities of stock have been relocated above the reach of flood waters. Emergency measures are generally less effective than permanent or contingent measures because they are more susceptible to carelessness or complacency.

Owners and managers of buildings are cautioned not to undertake piecemeal flood proofing measures such as installing standpipes or barricading entrances and store windows without professional assistance since such measures could worsen the flood damages.

Chapter III
Flood Proofing Procedures

Several general procedures to achieve flood proofing are discussed in this chapter. Some of these procedures, such as laying out sites and raising buildings, are intended primarily for new construction which would represent a proper use of flood plain sites. Other procedures, such as those to keep the water out or those to minimize losses if the water gets in, would apply to both new and existing structures.

Laying out the Site

The practice of "clustering" buildings is prevalent in planned unit developments. This clustering permits buildings to be attractively grouped on parts of a site which are above flood levels and reserves the low-lying sections as landscaped green areas and parking facilities.

The use of the higher ground for development allows streams and other natural lowland features to be kept intact as scenic elements and fish and wildlife habits. Many of the natural features of the valley can be made more useful for recreational purposes. For example, low-lying swampy areas can be transformed into permanent lakes that provide opportunities for water oriented recreation and modest amounts of flood water storage as well.

Where natural high ground does not exist, sites can be raised by filling, providing the fill does not interfere with the flow of flood waters. The concept of clustering buildings on higher ground, elevated by filling, is especially useful in metropolitan areas where a shortage of land may force the development of areas subject to low stage flooding.

Flood proofing measures can be designed to blend with the overall appearance of a structure. When this is done, a structure's appearance can be preserved and in some cases even enhanced by flood proofing.

Raising the Buildings

The practice of elevating a building on "stilts" to provide an "open" effect at ground level can also reduce the flood hazard. If some means of access is maintained and utilities can continue to function, activities would not be interrupted during floods.

The raising of the main floor level is practiced in much new construction throughout the country. There are examples of residential, commercial, recreational, and industrial buildings which have been designed and constructed in this manner. Where land is at a premium, as in central business districts, buildings are often placed on "stilts" with parking facilities on the ground level.

Desirable esthetic effects such as the creation of upper level pedestrian plazas above utilitarian lower level parking areas, can be integrated into a flood protective scheme in which the lower level can be flooded without affecting the pedestrian areas and buildings. Similarly, the contemporary practice of placing mechanical equipment on upper levels of multistoried buildings will minimize potential damage of valuable equipment and interruption of service during floods. Techniques designed for the more normal locations can be applied with little modification to buildings in flood plains, and result in structures which will suffer little damage.

The Farnsworth House in Plano. Illinois, is an example of this approach to flood protection. The house is on the banks of the Fox River and was designed by Mois van der Rohe with the floor level of the home raised on stilts to place it at an elevation above known flood heights. This design was developed to permit the use of a scenic riverfront site for a house location. When the record flood of 1960 occurred, the house proved to be above the flood waters.

Keeping the Water Out

The design techniques discussed above either achieve flood proofing through site planning and development or incorporate flood proofing in the initial construction of the buildings. The location and environment of structures in built-up urban areas may make these solutions impractical. In such circumstances, the building owner, architect, or engineer is faced with a job of designing flood proofing measures for existing conventional buildings which are exposed to flood water. These flood proofed buildings can incorporate many contemporary design features such as large window areas, pedestrian arcades, open flood space and curtain wall panels.

An example of successful flood proofing after construction is the Stanley House in LaGrange, Illinois. The house is located on a scenic site overlooking a golf course. After an experience with high water, the owner constructed a brick wall to close off the front and back porch areas, and added aluminum flood shields to close off the entrance ways. The owner, an artist, says the additions have not detracted from the home's appearance and have kept the house completely dry when there was water two feet deep all round it. Further details of the Stanley House are considered in Chapter V, on "Programs of Flood Proofing."

In designing new structures, or in altering existing ones, thought should be given to the use of receding flood shields which are normally hidden from view, but can be easily lowered or slid into place upon the receipt of a flood warning. Such shields also escape the danger of being misplaced.

When flood shields must be mounted on the street side of an opening, the brackets to which they would be bolted can be concealed with easily removed alumium strips or "skins."

While flood proofing measures must be functionally able to protect against a selected flood condition, such measures need not detract from the appearance of the structures. When the Pittsburgh Press Building was flood proofed, as an aftermath of the 1936 flood, the alterations transformed the outer appearance of the building. The large plate glass windows were replaced with many small windows of "unbreakable" glass that were embedded in reinforced frames. However, a recent face lifting of the building has made the flood proofing measures much less evident.

Internal Flood Proofing Measures

Owners of buildings which are subject to flood but cannot be easily altered to keep the water out, can consider the use of water resistant construction materials to reduce flood damage. Even owners of flood proofed structures generally able to withstand flooding would also be well advised to consider the use of such materials to reduce losses when flooding exceeds the protection level.

The property owner and his architect can substantially reduce the potential flood damage to a building through the careful selection of water resistant materials, but may be worth considering even when their use would mean higher material costs.

Examples are exterior grade plywoods and tempered hard boards in lieu of ordinary construction grade plywood and hard board. These materials can be utilized at a reasonable additional cost and under some conditions substantially reduce water damage. Also, in flood plains a waterproof plaster on galvanized wire lath could prove to be a more prudent long-term investment than gypsum board products which would have to be replaced after a flood. Metal windows, doors and door jambs which would not deform or warp when soaked may also be economical for buildings in flood plains.

In structures subject to flooding, all adhesives used to fasten floor tiles, wall panels and ceiling tiles, should be waterproof so that the adhesive will not fail when wet. Carpeting should be used which can be cleaned without any appreciable damage or evidence of mildew after inundation. Wall and floor surfaces should be finished in a manner permitting cleaning or hosing after a flood with a minimum of damage and deterioration.

Chapter IV

Structural Engineering Aspects of Flood Proofing

Flood proofing efforts to keep the water out of buildings fall, in part, within the province of the structural engineer. When flood waters surround a building, they impose loads on the structure and substructure beyond those it normally is designed to withstand. A determination of these loads is a prerequisite of flood proofing efforts.

This chapter discusses some of the more common structural problems that could be encountered. Because of the complexity of these problems, building owners who are contemplating flood proofing should engage the service of a professional engineer who has a working knowledge of structure and who has had experience with hydraulic structures or flood proofing. This is necessary to insure that the flood proofing does not increase damages by creating structural damages -- ruptured walls and floors -- in addition to the damages resulting from water contact and disruption.

Analyzing the Structural Problem

The forces which would act upon a typical building under conditions varying from normal (non-flood) to partial submergence (flood with and without subsurface or foundation drainage) are graphically presented in figures hereafter. The building cross-section shown is considered representative of that which would be commonly encountered in a flood proofing program.

Loading from Structure and Contents - The weight of the building itself (masonry, concrete, steel, wood etc.), known as dead load, together with the weight of its live load (furniture, machinery, merchandise, occupants, etc.) will normally be transmitted through the roof and floor systems to supporting columns and walls and thence to the foundations. These loads generally are transmitted directly to the supporting soil or bedrock under the foundation. Loads of this type will normally be unaffected by flooding and will have the same value for both flood and non-flood conditions.

Restraint from Floor and Roof Systems - Flooding produces large lateral forces on the structure. These forces will be resisted by the building walls, floor, and roof systems. Many commercial and industrial buildings are designed and constructed in a manner to provide adequate connection and anchorage between these systems for support and structural unity, but each building must be individually evaluated and strengthened where necessary.

Most residential and many light commercial and industrial buildings, however, do not have the necessary anchorage and would require modification to provide it. This would involve adequate transverse bridging in addition to anchorage into the walls around the entire perimeter. Steel angles bolted into both the floor system and the walls at their juncture would be one method of anchorage.

Resultant of Non-Flood and Flood Loading - The non-flood loading is the force exerted by the soil backfill upon the wall. These pressures depend upon the physical characteristics of the soil particles, the degree of compaction, the moisture content, and the movement of the wall caused by the backfill and foundation deformation, if any. Where the top of the zone of saturation (water table) is at an elevation above the base of the foundation, the pressure on the wall and floor slab is due to the bouyant weight of the soil plus the full hydrostatic pressure of the water. When a workable subdrainage system is provided to lower the elevation of the water table, the pressure on the wall will be reduced. The degree to which the water table can be lowered will depend upon the permeability of the soil and the efficiency of the subdrainage system.

Flood loading without subdrainage is the force of the full hydrostatic pressure of the water above as well as below the ground line plus the buoyant weight of the soil. As schematically illustrated in Figure 2, the magnitude of this force can be considerably larger than the force developed under nonflood conditions.

When subdrainage is provided, this flood loading force is reduced. However, in the case of an existing building with an existing unmodified, subdrainage system, prudence would dictate that no load reduction be assumed. Subdrains, where already installed, are generally provided only to intercept seepage and control uplift on basement floors due to ground water. If such a subdrainage system were to be modified to attain a known degree of effectiveness, a load reduction could be determined. Obviously, for new construction the subdrainage system can be designed and constructed to afford a predetermined degree of reduction of flood loads.

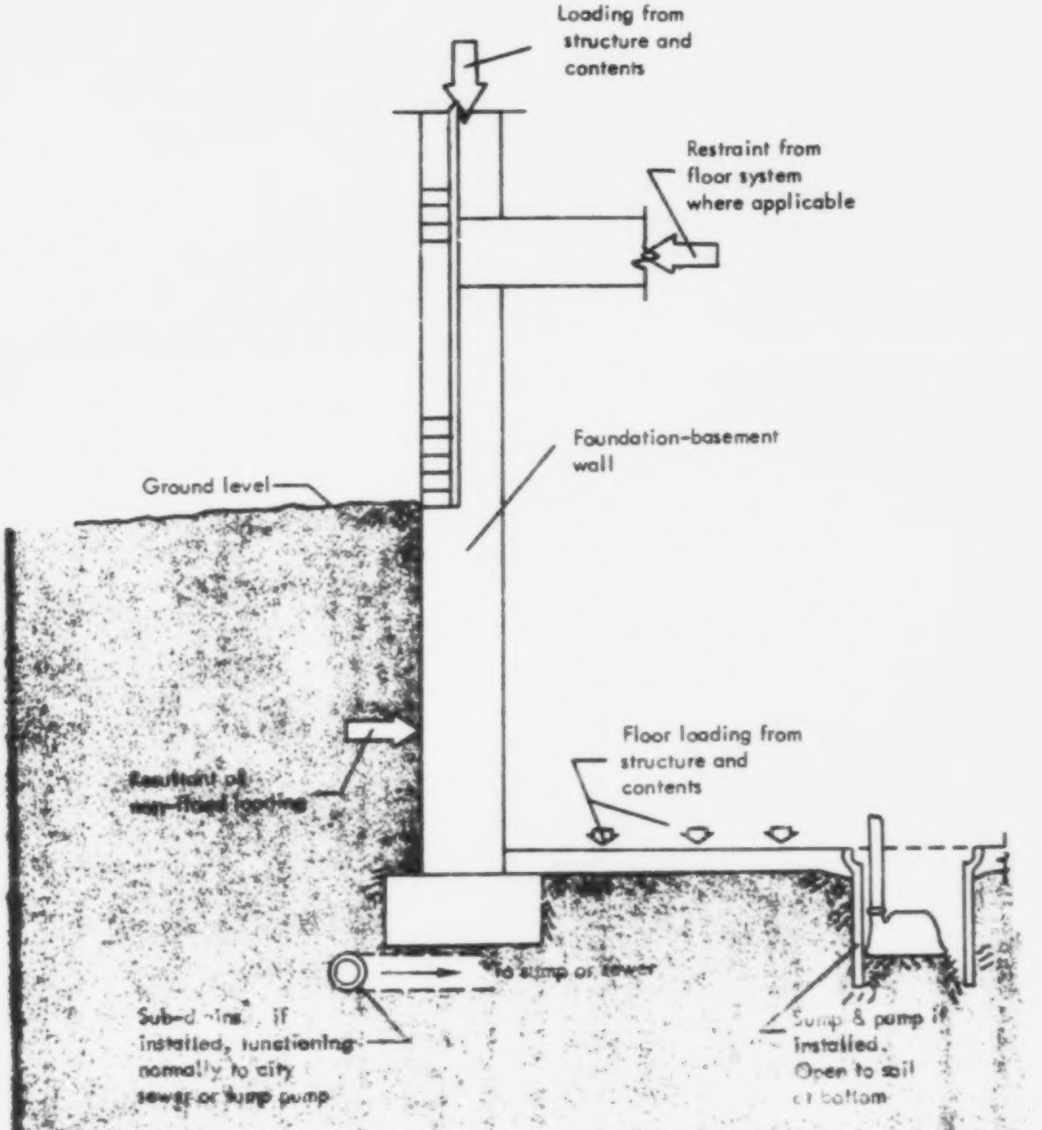
The magnitude of the flood induced forces that will be encountered is indicated by the fact that a one story brick building (3 5/8 inches of brick over wood frame) can be expected to withstand no more than two feet of water above the ground line providing the wall is in good condition. For brick with concrete block backup this height would be somewhat greater.

Subsurface Drainage

Ground-water conditions may adversely effect the stability of a building or structure either through uplift which tends to "float" the building or by erosion which can undermine the support. Investigation and analysis of the factors involved at any specific building and the design of control or corrective measures are endeavors requiring the attention of professionally trained personnel.

Ground-water problems can be controlled by the installation of subdrainage systems (see figures 1 and 3) to reduce the lateral forces on the foundation walls and floor slabs. Experience has shown that the composition of soils in a particular area can vary widely, with extreme ranges of permeability existing in areas of the same general geological origin. Such ranges in permeability argue further for careful investigation and analysis. The design of a subsurface drainage system must be based on the results of soil investigations of permeability and analyses of structural strength.

A sump and pump system can be employed to help protect the subsurface part of a building. The pump could be designed to accept storm and seepage flows and pump them to a point above the flood waters. The sump should be open to the soil at the bottom and to atmospheric pressure at the top within the basement. This would provide a fail-safe feature, in that power or pump failure would allow water to flood the basement and there-by tend to balance the outside flood induced pressures upon the basement walls and floor slab. As an alternative, a prearranged program of deliberate flooding with clean water could be employed to minimize the cost of clean up after a flood.


Loading from structure and contents
Restraint from floor system where applicable
Foundation-basement wall
Ground level
Resultant of non-flood loading
Floor loading from structure and contents
To sump or sewer
Sub-drains*, if installed, functioning normally to city sewer or sump pump
Sump & pump if installed. Open to soil at bottom

*Existence of subdrains depends upon the requirements of local building codes, ground water conditions, soil conditions, storm or combined sewerage systems if any, etc.

Figure 1.

[illegible]

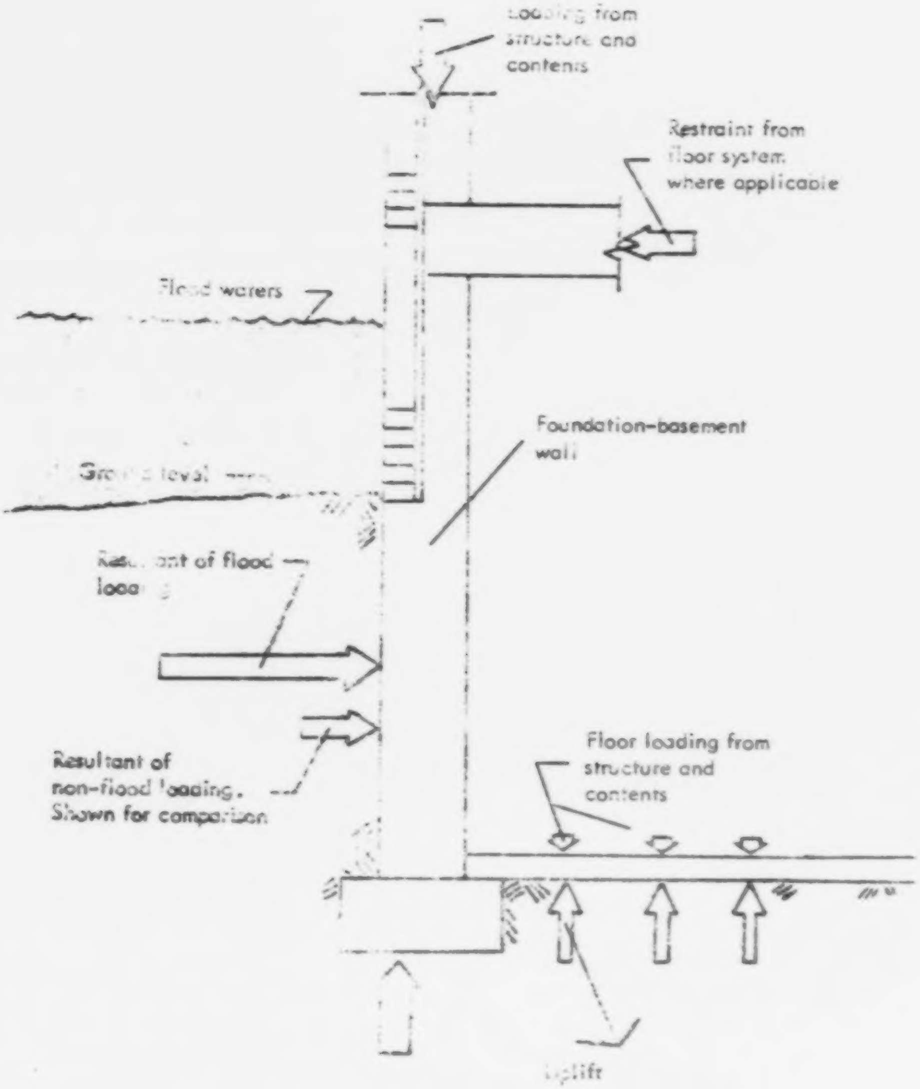

Loading from structure and contents
Restraint from floor system where applicable
Flood waters
Foundation-basement wall
Ground level
Resultant of flood loading
Resultant of non-flood loading. Shown for comparison
Floor loading from structure and contents
Uplift

Figure 2 - Typical building loads under flood conditions without subsurface drainage

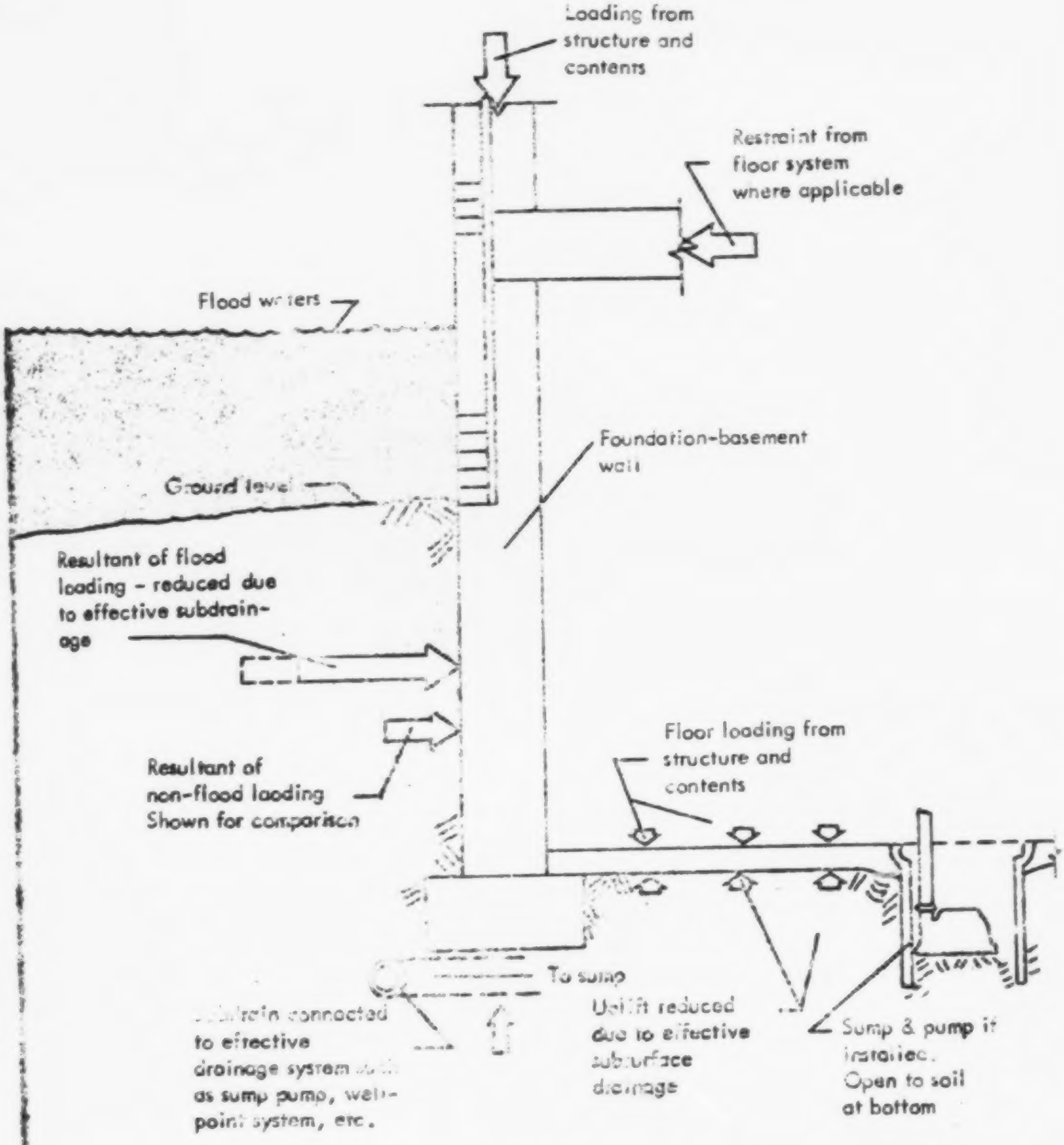

Loading from structure and contents
Restraint from floor system where applicable
Flood waters
Foundation-basement wall
Ground level
Resultant of flood loading - reduced due to effective subdrainage
Resultant of non-flood loading Shown for comparison
Floor loading from structure and contents
To sump
Subdrain connected to effective drainage system such as sump pump, well-point system, etc.
Uplift reduced due to effective subsurface drainage
Sump & pump if installed. Open to soil at bottom

Figure 3 - Typical building loads under flood conditions with subsurface drainage

Seepage Control - Foundation walls can be made watertight to minimize water infiltration through cracks and crevices in the walls. In buildings under construction, this can be accomplished through the use of waterproof membranes and seals. Construction joints can be protected by the use of a neoprene or other similar waterstop. Existing masonry or stone foundations are more difficult to waterproof, particularly if the mortar joints have deteriorated with age. Sealing of walls to prevent seepage can be accomplished in many cases, however, by coating them, preferably on the exterior, with hydraulic cement, epoxy paint, or other similar waterproofing materials.

It must be recognized that sealing and waterproofing of walls increases the hydraulic forces acting on the walls unless the drainage through the walls which is afforded by the cracks and crevices prior to sealing is provided by other means. Sometimes the wisest course would be to permit the seepage through the wall and then control it by a floor drain and sump pump. Existing cracks and leaks in walls sometimes can be the most practical form of drainage to relieve pressure. In some cases this drainage can be supplemented by holes drilled through the walls. Structural and hydraulic analyses of alternative designs and associated cost estimates will enable the designer to choose the most suitable means of controlling seepage at a given building.

Sewage Backup - Most existing subdrains, whether connected to sewerage systems or not, are subject to backflow and high pressures during floods. Since these high pressures could burst the usually encountered clay pipe subdrains and endanger basement walls and floors, some device such as a gate valve must be provided for protecting or isolating the subdrains around the building from these high pressures.

There are several alternative methods for controlling backflow through sewers. One method would be to install a main valve at a location where the sewer is strong enough to resist the flood induced pressure and where all possible reverse flows can be stopped. This valve should be designed to accommodate grit and other materials which could lodge in it.

If the pipe is of sufficient strength, an alternative would be to install separate valves on all basement fixtures and floor drains. These valves could be inflatable rubber plugs or a similar type of mechanically expandable rubber plug. Valves designed for low pressure (20 psi and less) could be installed in drain lines of fixtures which are below design water levels. In either of the above alternatives, it would be necessary to provide adequate sump pumps to handle any leakage.

Another alternative for controlling sewer backup provides for outletting all floor drainage, appliance drainage, drain tile flow, and any seepage that might enter the building, to a sump pump. The pump would lift the drainage up to an elevation above the design flood on a permanent basis. By thus eliminating all gravity sewer drains, the problem of flooding backflow can be eliminated and a subsurface area permitted to function during floods.

Structural Engineering Observations

The highly technical and thorough nature of the investigations and analyses required in the design of effective, safe, and reliable flood proofing measures for both new and existing facilities cannot be over stressed. Construction of new, or modification of existing subdrainage systems without such investigation and analysis can result in a situation potentially more dangerous to life and property than no flood proofing program at all.

The large number of factors and the potential magnitude of the forces involved make it impossible to design flood proofing measures by intuition. Such an approach can lead to loss of property and even life during a flood, with all the attendant legal problems in addition to the disruption and misery.

Chapter V
Programs of Flood Proofing

Under the general guidelines discussed in the previous chapters, the flood proofing of each building must be separately examined, since the approach and measures required will differ for each structure. Also, the flood proofing program for a particular building may consist of several types of measures -- permanent, contingent, and emergency -- as discussed in Chapter II.

A realistic level of protection can be determined when the building owner or manager, his architect and his engineer recognize the nature of the flood situation in their locality, the strengths and weaknesses of the structure, and the condition of the soil under and around the foundations.

The various aspects of a flood proofing program are discussed in this chapter. The illustrations presented are examples of flood proofing measures that have been installed as parts of protection programs for existing buildings.

A Standard Operating Procedure

Any individual or organization undertaking a contingent or emergency protection program must have a standard operating procedure to carry out the flood proofing measures when the need arises. Some buildings can be "buttoned up" in a short time while others may take considerably longer. The time element will depend upon the number of actions involved, the complexity of the program, the number of employees available, their understanding of the program, and their ability to handle assigned tasks. Order and advance planning are important factors. Each flood proofing system should have a timetable or check list keyed to flood stages. The call out of manpower and the assigned actions of work crews can follow a mobilization schedule which corresponds to the rise of the flood waters.

The flood proofing system should be designed so that it may be put into operation as quickly and as simply as possible. Flood shields, doors and hatches may have to be handled during the most adverse weather conditions (perhaps during the stormy weather which causes the flood), so lightweight metals should be used wherever possible.

Flood proofing items including bolts, gaskets, caulking, timbers, and flood shields should be stored for easy access. The larger more bulky items should be stored close to the point of insertion and when possible in such a manner that they can be easily slid or dropped into position. One lost or improperly mounted flood shield, or the failure to valve off a sewer, can undo an otherwise perfect plan. Flood shields at the Pittsburgh Press Building have been mounted on the outside walls close to the points where they would be used. A numbering or coding system has been developed so shields can be matched readily to the proper openings. Nuts and bolts for mounting the shields are bagged accordingly.

Maintaining a State of Readiness

In addition to the development of an actual flood proofing program, a procedure must be developed to maintain a state of readiness. One technique to keep flood proofing measures operational is periodic testing. In Pittsburgh, for example, the Horne Company's insurance firm formerly required that once a year the flood shields which protect window, door, and other openings be put in place and sealed, just as they would be during the time of a flood. This requirement has now been waived and instead the insurance company requires a thorough annual check of the state of readiness of each item in the program. A company flood manual is used to acquaint personnel with area flood problems and to outline specific tasks to be performed should an emergency arise.

Complacency can be the ruin of any flood program. The longer the interval between floods, the greater the feeling that "it can't happen again." Long flood-free periods tend to dull the awareness of the need for flood proofing.

A check of management readiness is almost as important as the examination of the physical elements of the system. If management becomes complacent, this complacency will be reflected in the attitudes of employees and the system will develop serious gaps as time progresses. As new employees replace older ones, the flood problems move from the realm of personal experience to hearsay. This can be guarded against with employee education, assigned duties and perhaps even flood proofing drills.

The Subsurface Part of the Building

Newly designed buildings may have machinery located on the upper floors but most older structures have the electrical machinery, the heating and the pumping equipment on lower floors. It is these lower, subsurface floors, which first experience flooding problems from seepage and sewer backup. Since flood proofing systems often require pumps, electrical equipment and emergency generators as an essential part of the operation -- these must be kept in working condition throughout the crisis.

When buildings have entrances to subsurface levels which lead out onto ground level, these entrances should be adjusted to prevent the entry of overland flow. A stairway opening could be flood proofed by encasing the entrance with a concrete block wall treated with asphalt and installing a watertight bulkhead door. To increase the strength of such a wall, the block cells could be filled with concrete and steel reinforcing rods.

Several buildings subject to flood have installed low protection walls around furnaces, air-conditioners and other valuable equipment to protect the equipment if water accumulates in the basement. This approach may prove most desirable when the basement floor is not adequate to withstand hydrostatic pressure, so that flooding to a few feet is allowed to prevent the floor from cracking or rupturing by equalizing the pressure. In some cases pumps are operated from the "safe" islands to control the water depth in the other parts of the deliberately flooded basement. Only enough water is allowed in the basement to prevent structural damage.

An alternate method of protecting valuable equipment would be to "mothball" it by applying a coating of grease, by spraying with parafin or plastic, or by enclosure in waterproof polythene or vinyl film. Equipment so protected can be submerged for considerable periods and later put back in operation with a minimum of expense compared to the cost of restoring unprotected equipment.

When none of the above measures is possible, or in the case of an emergency, it is suggested that the motors, other vital electrical relay components and mechanical equipment be removed and stored above floor level. Even if this cannot be done, much of this equipment can be restored to working condition by proper salvage even if inundated. Salvage of equipment and materials can be another method of reducing flood loss. The goal of flood proofing is loss reduction, however it is accomplished.

Termination of Utilities

When flood proofing a building, provision should be made to eliminate the threat of flooding by way of gas mains, sewers, conveyor systems and water pipes or drain tiles which enter the building. Gate valves or one-way swing valves can be installed in utility pipes to provide protection against the threat of this source of flooding.

Vitrified clay pipe should not be used within the confines of building walls, and they should never be located next to an entry valve. If sewers are to be valved off they should be cast iron, steel or reinforced concrete. Otherwise the pressure built up in the line could cause a rupture.

Fuses and circuit breakers servicing flooded building areas should be clearly marked and easily accessible. Electrical circuits serving lower building levels should be designed or modified so that they can be cut off if flooding begins. This will protect against fires and loss of life due to electrical shocks. As another precaution, valuable electrical appliances which cannot be moved should be disconnected at the unit to prevent short circuiting and damage to their power components.

Continuation of the Building Systems

Unless a building is to be completely evacuated during a flood, provision should be made for continuing essential building systems at least on a limited basis. First consideration should go to locating central telephone equipment and electrical transformers above flood level. In addition, auxiliary generators should be available to provide energy during a power failure for temporary lights, vital pumps to control seepage, and elevator operation.

Sewer systems can be kept in operation through the use of shut off valves to prevent backup and the installation of pumps. The same pumps can also remove seepage from the building if outlets are provided which extend above known flood stages. Check valves, vacuum breakers or air gaps should be installed to prevent back siphoning.

Water mains normally are kept under sufficient pressure to avoid contamination by flood waters. Pressure should be increased during floods, however, to compensate for the increased head acting on the mains. If the pumping station is flooded, however, pressure will be reduced and contamination can occur. This suggests an internal water supply, perhaps a roof storage tank, to keep buildings in operation during floods. It is also advisable to provide cutoff valves to isolate any portion of a building which may be flooded to prevent contamination by back siphonage into those parts which are not inundated. Where water wells are located on flood plains, their casings should be sealed and extended above anticipated flood levels to prevent the entry of polluted flood waters.

Storage tanks may contain products necessary for a building's operation. They should be anchored and weighed down or else raised above flood levels to prevent flotation and loss during floods.

Closing Wall Openings and Vents

Windows and vents both above and below the surface should be sealed to prevent the entry of flood waters. They may also need to be reinforced. Care should be taken, however, that the walls are strong enough to support the pressures added by vent and window reinforcements. Also, the wall itself should be treated or constructed to prevent large amounts of water from passing through it.

Openings which are no longer necessary, such as old coal chutes, windows into storage and basement areas or unused doorways, can be permanently closed and sealed by masonry or reinforced glass block construction. Masonry enclosures should be "keyed" into the existing masonry in a manner similar to the original construction.

Where openings in exterior walls are necessary to the everyday function of the buildings, there are several flood proofing alternatives. A variety of materials and combinations can be used in window closure. Possibilities include the partial bricking in of wall openings with or without metal shields; the use of wood timbers which fit in slotted jamb supports, and the provision of full metal shields. Any material can be used providing it prevents the entry of flood water.

Display Windows

There are several approaches to adjusting display windows to prevent the entry of flood waters. Since these windows are so vital to store operation, they must remain attractive and function as a place of display for as long as possible. One approach is to equip the display window with an aluminum flood shield which can be bolted into place on the inside during floods but which can be stored at the back of the display area at other times. When a flood is expected, the contents of the window are removed and the shield moved forward on a track and bolted into place approximately four inches behind the glass. Rubberized gaskets provide the waterproof seal around the edges of the shield.

"Weep holes" are openings provided at the base of a window frame to be opened when the shield is bolted into place. This permits flood waters to enter behind the glass to counter the outside pressure and prevent breakage. At such installations it is also necessary to protect the glass window from floating debris or ice. Rigid awnings, timbers or metal screens can be placed in front of the window for this purpose.

Another type of flood shield arrangement is one that is counter-balanced on the inside and above the window. This method allows an "open" view of the store interior.

Flood shields can be designed to protect against a much lower flood, closing off only the lower part of a window.

Display windows can also be flood proofed by placing flood shields on the outside. Such shields will have to be stored elsewhere and carried into position when needed. An advantage of outside shields is that there is no need to protect the glass against the impact of debris or ice. It would be desirable, however, to provide openings to permit drainage of any seepage that might collect between the temporary closure and the glass. This drainage would be channeled into the building and pumped out above the flood levels.

There are advantages to both inside and outside flood shields. If ths shields are on the outside of the window, the water pressure against them helps to seal the shield against the framework. If the shield is on the inside, it is within reach. Checks for leakage can be maintained and any problem with a shield can be corrected more easily if the bolts are inside and accessible rather than outside and perhaps submerged.

Pedestrian shopping arcades or first-floor-level setbacks lend themselves to flood proofing measures. Here the flood shields are hinged from the ceiling on the outside of the windows. They are tied back against the ceiling in their stored position.

Another method of flood proofing large window areas which are not used for display purposes is employed in the Pittsburgh Press Building. In this case the large windows were replaced by small panes of 5/8 inch structural glass inserted in a steel grid designed to resist the hydraulic loads imposed by the flood waters. This window construction resists the entry of flood water while still providing a source of natural light.

Doorways

Whether a doorway is for public, personnel or freight use will influence the measures employed to effect closure during a flood.

At a public entrance the framework installation for a flood shield should either be covered during flood-free periods or designed so that it will not detract from the physical appearance of the doorway. Flood shields can be counterbalanced above doorways and recessed into the ceiling during storage. When a flood warning comes, the shields are pulled down and bolted into place.

Another measure is to raise doorway thresholds, with access, provided by gently sloping pedestrian ramps. The height of the sill will determine the level of permanent flood proofing. In some cases this level can be raised by using contingent and emergency flood proofing measures.

At entrances for building personnel or other service entrances, flood shields can be entirely functional.

Flood shields can be secured in a number of ways. Some shields are bolted onto their frames only on the tops and bottoms, while others are bolted against the receiving frames on the sides. Whatever the method used, care must be taken to assure that the gates have a watertight seal against the frame. This can be achieved by applying uniform pressure on the gasket or seal through a proper design of bolting patterns and by using caulking compounds, binding agents, oakum, or lead wool, to control leakage.

Flood shields for doorways need not cover the entire doorway, they may only extend to the elevation of the selected flood protection level. Because of structural limitations, the building may be equipped with flood shields to protect against only a three-foot flood stage. If that stage is exceeded, this flood proofing measure will be overtopped hereby avoiding the build-up of pressures which could cause structural damage.

Flood proofing must be complete up to the selected level of protection. If an entranceway cannot be protected by a watertight flood shield because of its design, it will need to be closed off by emergency measures such as sandbags over vinyl sheeting backed with timbers.

Evacuation of Contents

When it is not possible to prevent the entry of water, temporary evacuation of building contents such as retail merchandise, records, files, office equipment, machinery, supplies and other valuables can significantly reduce flood damage providing sufficient warning time is available. Materials located on lower levels of a building in a flood area can be mounted on rollers or moveable pallets for easy transfer to a flood-free elevation. Figure 44 shows moveable counters used in the basement of the Horne Company department store in Pittsburgh. When floods threaten, they become vehicles for transporting the merchandise they contain as well as other items which can be stacked on top.

The Horne Company's flood manual contains a schedule for the removal of merchandise from the basement and first floors to higher floors as specified flood heights are reached. The floor areas are zoned and merchandise from a particular zone is moved to an assigned area on a higher floor. Each zone has specific elevators assigned to it and store employees are organized in teams to handle the movement.

An orderly plan of merchandise removal means faster, speedier recovery from flood effects by store, office, or factory. Less "shut-down time" means smaller flood losses since a drop in sales or production attributable to flooding is as much a part of the flood loss as the direct damage to property.

Flood Proofing Houses

Houses should not be located on flood plains when suitable sites are available on flood-free land. In some places, however, there may be no choice, especially where virtually an entire urban area, including the residential sections, is subject to inundation. Residential construction does not lend itself readily to flood proofing because of the extensive use of materials that do not impede the passage of water. Moreover, houses are seldom designed to withstand any significant horizontal pressures.

Where circumstances require the location of a residence on a flood plain, certain flood proofing measures can be incorporated into the design of the house as discussed in Chapter III.

In most cases in which an owner has purchased a finished house in an area subject to flooding, his success with flood proofing will depend on whether flood stages are low on his property and whether the outer walls of the structure are reasonably impervious. Under these conditions, flood shields can be designed to restrict the entry of water through openings in the walls, providing the walls are strong enough to resist flood induced pressures. This approach is illustrated in sketch form in Figure 45 and photographs of an application of it are shown in Figure 46. To be effective, the flood proofing program must also include measures to cope with sewer backup and ground-water seepage.

Homeowners who have suffered severe basement flooding should consider the relocation of furnaces, hot water heaters, washers, dryers, air conditioners, freezers, refrigerators, power shop equipment and other appliances as a permanent flood proofing measure. The length of the list dramatizes the large investment many people have in items which often are located in basements subject to flood damage.

A Flood Proofing Plan for a Structure

The flood proofing of a structure is analogous in many respects to making a ship watertight and seaworthy. Flood proofing involves not only adjustments to the foundation and substructure, but also modifications of those parts of the superstructure that are below anticipated flood levels.

A Flood Proofing Checklist

Some major items that should be considered in any plan for flood proofing a building are:

For Foundation and Substructure

1. Closure of openings including doors, windows, and vents.

2. Waterproofing and/or reinforcement of basement and foundation walls.

3. Reinforcement or drainage of floor slab.

4. Valving off or termination of entering utilities

5. Continuation of internal building utility systems.
6. Protection for immoveable equipment.
7. Plans for the removal of stock.
8. Procedure for implementing flood proofing.

For the Superstructure

1. Closure of windows, door and vents.
2. Anchorage and reinforcement of floors and walls.
3. Use of water resistant interior materials.
4. Evacuation of contents.
5. Reorganization of space.
6. Emergency protection measures.
7. Procedure for implementing flood proofing.

As noted on the checklist, measures requiring the presence of trained or experienced personnel are important features of a flood proofing program.

Flood Proofing Benefits and Costs

To be economically sound, the incremental benefits which would accrue from flood proofing a structure should equal or exceed the cost of flood proofing. A survey analysis of Bristol, Tennessee-Virginia, showed that flood proofing could be economically feasible and could be considered as an alternative to flood control programs.

Community Benefit - Cost Findings - Certain substantial structures in Bristol which represented large investments and would suffer heavy losses if flooded, were found to be the structures that could be most readily flood proofed. It was shown that selective flood proofing of these structures would result in extremely high benefit-cost ratios. Sixteen structures in Bristol were found to account for 62 per cent of the total potential damage from a recurrence of the 1929 flood of record and 36 per cent of the total potential damage from the regional flood.

Subsequent studies of the feasibility of flood proofing selected structures in four other communities have been carried out by the cities with technical assistance by the Tennessee Valley Authority.(1) In these studies, flood proofing was considered as a part of a comprehensive plan for flood damage prevention. It was employed in these plans primarily to reduce the residual damage that remains after partial protection by a flood control project.

In Athens, Tennessee, an analysis of the feasibility of flood proofing several of the substantially constructed buildings showed that in the course of time, the benefits in flood damage avoided would outweigh the initial cost of flood proofing by approximately 5 to 1. Similar ratios of benefits to costs for flood proofing selected buildings were found in other studies.

Benefit-Cost Factors - Though the economic feasibility of flood proofing has been demonstrated for substantial buildings in several small cities, the comparative costs of flood proofing particular buildings will vary considerably depending upon:

1. Local flood characteristics,

2. The type and size of the structure to be flood proofed,

3. The extent of efforts to make the measures esthetically pleasing, and

4. The financial terms of capital invested in flood proofing.

Correspondingly, the potential benefits that would accrue would vary with:

1. The amount of investment in the structure,

2. The intensity of use, and

3. The elevation to which the flood proofing measures are carried.

The economic feasibility of a flood proofing plan for a specific building should be based on an evaluation of the above factors for the particular building. Once the potential flow of benefits has been established on an average annual basis and the average annual cost estimated, the feasibility of flood proofing can be expressed in benefit-cost terms.

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(1) In addition to Bristol, the communities studied were: Athens, Redbank-White Oak, and Sevierville, all in Tennessee, and Coeburn in Virginia.

Tax Considerations - Another point that deserves attention is the tax aspect of flood proofing. At present, the attitude of the Internal Revenue Service toward flood proofing measures appears to be generally favorable. The amount of depreciation allowed and the rate of depreciation would be influenced by the nature of the material used.

The main point is that the expenses of flood proofing could to some extent be used to reduce one's tax liability. This fact might lower the real cost of flood proofing and might influence the decision on whether or not to flood proof. Local Internal Revenue Offices should be consulted to determine the specific tax effect of flood proofing a given building.

A Flood Proofed Structure

For full effectiveness both the technical and financial aspects of flood proofing should be co-ordinated in a total plan for each building. Each flood proofed building should have such a plan to show the relationship among the various protection measures. In addition, costs should be associated with each of the measures depicted and alternative financial solutions defined to determine both feasibility and the optimal amortization schedule. An evaluation of such plans would assist in determining the adequacy of a flood proofing program.

Flood proofing of selected buildings can be an effective means of reducing potential flood losses. It merits consideration when plans are being formulated for flood plain management. Its availability broadens the range of choice that property owners can consider when faced with the need for taking action to reduce flood risk.

MAKING FLOOD WARNINGS MORE TIMELY

Marshall M. Richards

Hydrologic Services Division
Office of Hydrology. Weather Bureau
Silver Spring, Md.

INTRODUCTION

Despite large expenditures for the construction of flood control structures, flood damages in most areas continue to increase. Simple economics make it impractical for the engineer to provide protection to many areas subject to flooding. This being the case, many localities must deal with each flood event as it occurs. In these situations the availability of timely flood forecasts is extremely important.

Flooding usually results from one of two meteorological situations. The more common of the two is the river flood resulting from excessive precipitation and/or snowmelt. Along coastal areas, however, flooding is primarily the result of a wind-driven storm surge superimposed upon the astronomic or periodic tides. Forecasting for these two different types of flooding require entirely different basic data and forecast procedures. This paper deals entirely with the river floods.

People who live in flood plains, but who do not have water control structures to protect them have three basic actions open to them in case of an approaching flood. They can (1) erect temporary protective structures such as levees (2) evacuate people and move their property to a safe location (3) waterproof property that cannot be moved to minimize water damage. Some combination of the three is, of course, often the best solution. These actions all take time. Cooperative action by public and private agencies, if they can arrive on the scene in time, can make such an operation reasonably successful. The matter of timing is critical and a timely flood forecast is invaluable. The snowmelt flood in the upper midwest of the United States of America (U.S.A.) in the spring of 1969 provides an excellent example of what can be done when adequate time is available to prepare for a flood situation.

FLOOD FORECASTS AND OPERATION FORESIGHT[1]

In the winter of 1968-69 heavy snow and low temperatures occurred in the upper midwest of the U.S.A. in December. In early January the Weather Bureau was already alerting other government agencies to a serious flood potential. Thus, these agencies actually had as long as three months in which to plan relief activities and build temporary protective structures.

Special snow surveys in early February confirmed that the situation was serious. The first formal forecast release was made on 11 February, 1969, with additional details included in releases on 20 February, 27 February and 6 March. On 13 March a complete, detailed snowmelt flood outlook for 225 forecast points in the area was released. Record or near-record stages were predicted for over half of these points and major flooding for most of the remaining points. These forecasts indicated that over a million residents would be affected.

The early warnings were based on the assumption of a sequence of normal values of temperature and precipitation. As time passed these normal values were replaced by the observed data.

On 28 February the Weather Bureau briefed officials of many government agencies on the flood threat. Based on this information Operation Foresight was initiated on 1 March, making possible preparedness activities on a scale never before attempted. Most rivers in the area crested in late March or early April.

Temporary flood protection measures taken as a result of Operation Foresight provided net savings estimated at well over $100,000,000[2]. In fact, the net savings in this flood were approximately equal to actual damage. Since the flood damage figure includes the cost of the temporary flood protection measures, this is a classical example of the value of early action.

Admittedly, Operation Foresight was an unusual event. At the present time it is only when precipitation falls as snow and is temporarily stored as a snowpack that flood warnings can be made so far in advance. Even when compared to other snowmelt floods, 1969 was unusual. The abnormally large snowfall occurred relatively early in the winter season, making it possible to issue warnings even further in advance than usual. In 1965, for example, a flood of slightly larger magnitude in almost the same area resulted from large snowfall amounts late in the winter and warning times were much shorter.

LENGTH OF WARNING TIME POSSIBLE

In the areas where snow is only a minor factor in producing floods, the lag time between storm rainfall and resultant flood crests is often a matter of a very few hours in headwater areas. This time advantage increases to days or even weeks at downstream points and to a month or more at few downstream points on very large river systems such as the Mississippi River. Once a flood-producing storm occurs, there is usually a limited amount of time to make preparations for dealing with the flood and the flood forecaster must make every possible effort in order that his predictions reach the user at the earliest possible time. With this in mind, let us consider some of the factors affecting how much warning time it is possible for the river forecaster togive the flood fighter and how these warning times might be increased. For the purpose of illustration let us consider a river basin with two towns with flood problems as shown in Figure 1.

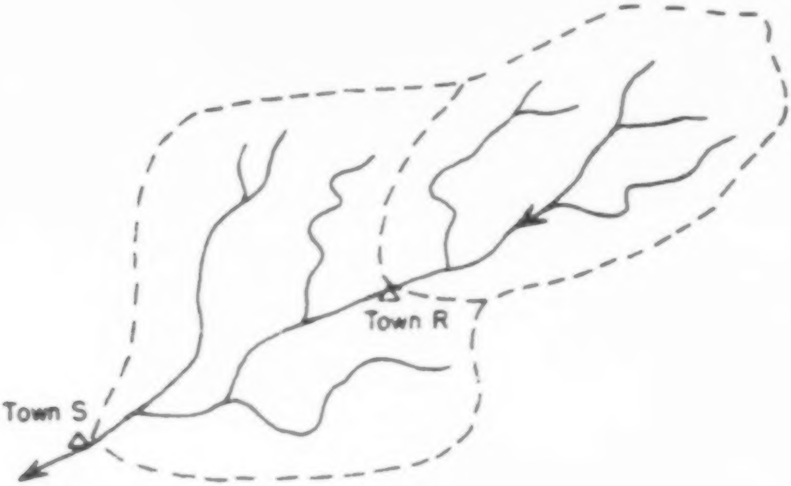

Fig. I. River Basin Map

Possible warning times vary with the size of the basin, its physical characteristics andwith various characteristics of the storm (or storms) that produce the flood such as duration, intensity, areal distribution, and amount of rainfall. Figure 2 presents a sequence of events for the prediction of flood crests at towns R and S (Figure 1). Since we are considering specific areas and antecedent conditions, the assumption of a specific storm event fixes the timing and magnitude of the resulting floods at towns R and S.

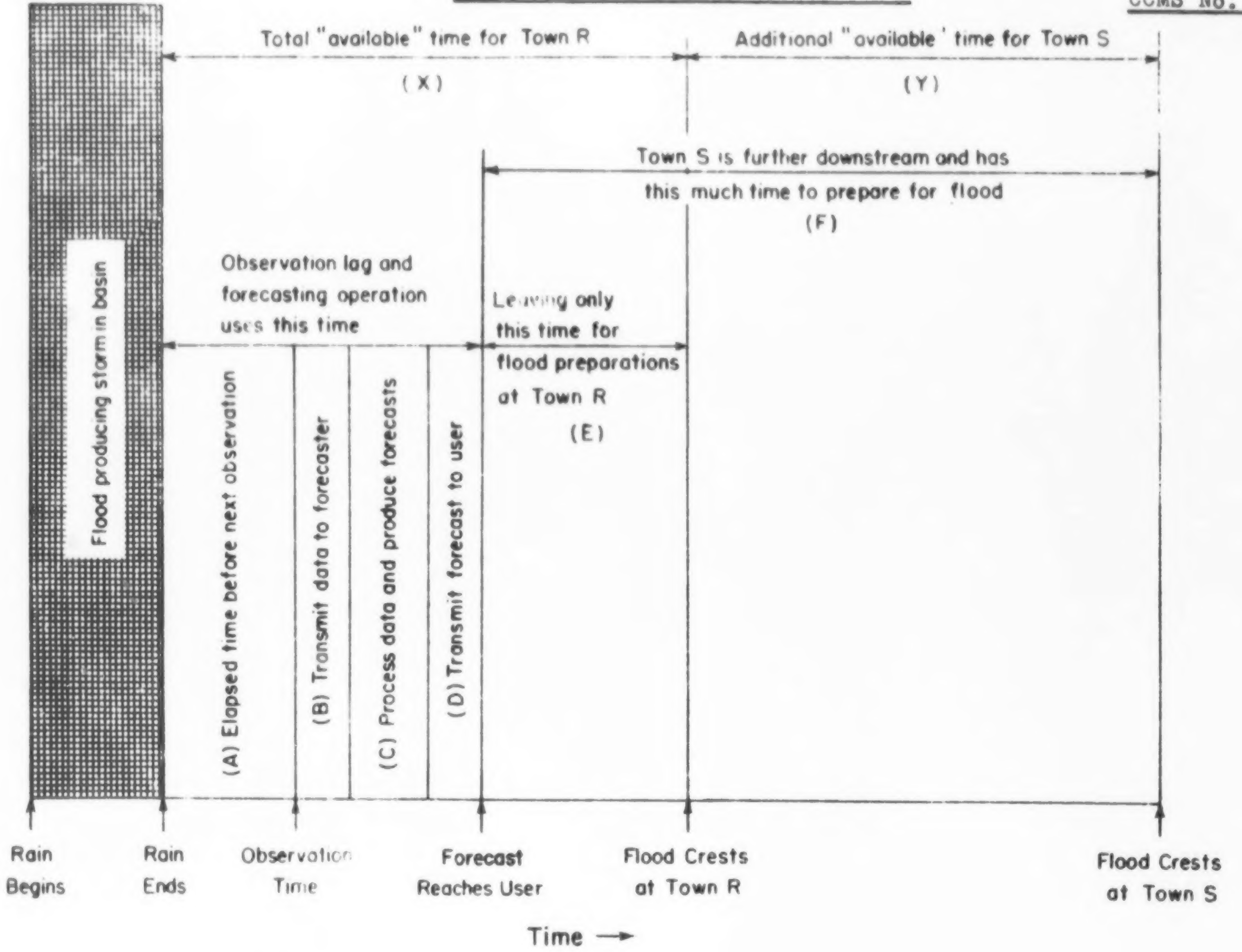
Total "available" time for Town R
(X)
Additional "available" time for Town S
(Y)
Town S is further downstream and has this much time to prepare for flood
(F)
Flood producing storm in basin
Observation lag and forecasting operation uses this time
Leaving only this time for flood preparations at Town R
(E)
(A) Elapsed time before next observation
(B) Transmit data to forecaster
(C) Process data and produce forecasts
(D) Transmit forecast to user
Rain Begins
Rain Ends
Observation Time
Forecast Reaches User
Flood Crests at Town R
Flood Crests at Town S
Time →

Fig. 2. Schematic of sequence of events during a flood situation.

FORECASTING DIRECTLY FROM RAINFALL

In order to serve upstream points such as town R, techniques have been developed which make it possible to forecast floods directly from observations of the rainfall.[3] With this capability, the sequence of events shown in Figure 2 are now appropriate. Since it has proven extremely difficult to forecast quantitative amounts of precipitation, the forecaster usually bases his forecasts on observed rainfall. As was indicated earlier, the elapsed times from the end of heavy rain until the flood crest reaches towns R and S are functions of various physical characteristics of both the drainage basin and the storm which produced the flood. The forecaster must predict how long this time will be. For purposes of this discussion, this period has been called "total available time" and given the dimension of "x" for town R and "xty" for town S.

As shown in Figure 2, the amount of warning time the forecaster can give town R (assuming he waits until the flood producing precipitation is actually observed) is the available time "x" less the time required to:

(A) Observe river and rainfall date

(B) Transmit data to the forecaster

(C) Process data and prepare forecast

(D) Transmit forecast to user

With the available time fixed, the forecaster must minimize the time required to complete these operations in order to maximize the time E (Fig. 2) in which the user must prepare for the flood. The question becomes - how can the time from the end of rainfall to the time the forecast reaches the user be reduced?

Modern technology offers many possibilities for cutting the time required for each step in the forecast process (A-D). This paper deals with some of the steps taken in the U.S.A. to reduce these "processing times" and allow more time for the community to prepare for nature s onslaught.

CURRENT DATA COLLECTION PROBLEMS

A major weakness of many flood forecasting systems is the system for collecting rainfall and river stage data. In the U.S.A. almost 90 percent of the river and rainfall observations required for flood forecasting are made by private citizens who are paid nominal amounts for performing this service. These observers must travel to the gage site at each observation time, manually record the required information, travel to a telephone, and transmit the data to the responsible Weather Bureau Office. Actually, most observers read their gages each morning, but report them only when the river level exceeds a predetermined height or the rainfall in the past day has totalled one-half inch or more. The observer continues to report every six hours until the river falls below the predetermined stage and there has not been any additional precipitation in the previous six hours.

The greatest advantage of a manual system is that it is relatively inexpensive. In addition, the observer has an opportunity to relay related information to the forecaster, such as current weather, river conditions, type of precipitation, etc. that may be useful. Numerous faithful observers do far more than is expected of them for the pay they receive, but in today's affluent society these good observers are becoming more difficult to find. The system also has a sizeable built-in delay due to the fact that the observer can very rarely be prevailed upon to make observations at intervals of less than six hours. If rain ends one hour after the official observation time, five hours will elapse before the observer makes the next reading and then relays this information to the forecaster. It is nearly impossible to get midnight data, and in some cases almost twelve hours may elapse before the observer actually records the rainfall total.

After the observation has been made, there is still the time-consuming process of transmitting the necessary river and rainfall data to the flood forecaster. The telephone is the basic means of collecting current hydrologic data. Even for relatively small river basins there may be several reports and for larger basins this number may well run into the hundreds. Answering all of the calls from the observers and manually recording them for the forecaster often requires an hour or two. Use of the telephone for collecting data also allows a chance for errors in transmission, particularly where reports originate in remote areas with relatively poor telephone equipment.

TIME SAVINGS FROM AUTOMATIC DATA COLLECTION

Manual collection of data for flood forecasting is economical, but it can be costly to the flood victim who had too little time to prepare.

Automation of the data collection process can greatly reduce collection times (A+B in Figure 2) and is entirely possible today. Several automated systems have already proven operationally practical.

Use of Telephone Systems

The initial step toward automation in the U.S.A. has utilized a telemetering sensor to interface with a telephone system, which delivers its intelligence as a series of audible tones, which must be carefully counted in order to interpret the desired river and/or rainfall data. This enables the forecaster to obtain data at any time of the day or night, thus making it possible to cut the elapsed time (A in Fig. 2) between the end of rain and the observation. A principal disadvantage, however, is that it is necessary to place a telephone call to each sensor and then patiently count the tones that impart the required data. This process consumes a minimum of about three minutes per report and the time required to actually collect the date (B in Fig. 2) has not been reduced materially. Therefore, although this means of collecting data is quite useful in obtaining critical key reports, the time required for collection eliminates it as a possibility for large scale networks.

An obvious solution to problem of automating data collection is the use of dedicated (single-use) telephone lines. The Weather Bureau has used this system on a 20-station network in the Potomac Valley near Washington, D.C., for a few years. The time required for dialling is eliminated since the lines are always connected. Readings are transmitted in seconds since manual interrogation is eliminated. Mechanical problems have plagued this network, but these could undoubtedly be solved. Much time can be saved but the high cost of leasing the dedicated telephone lines appear to make this approach feasible only for small networks for very special applications.

A compromise solution using regular telephone lines has been tested experimentally and may soon become operational in the Weather Bureau. The system utilizes a conventional teletypewriter and automatic telephone dialling equipment. The dialler is fed a tape with the telephone numbers of the gages for which the forecaster requires data and calls each of them in turn. The data are returned at relatively high speed - a second or two - and are printed on the machine. Since it does not use dedicated telephone lines, the cost is not high. The data are received in printed form and/or on tape which can be fed directly into a computer. No manpower is required at the Weather Bureau office to either take calls from observers or to manually dial a station. There is, however, the 30-40 seconds required to complete each call that limits the number of reports that can be collected by a single system such as this to about 80 reports per hour. However, several such systems could be employed in parallel if the economics justify it. Savings in time and manpower over manual methods are great and flood warnings could reach the user as much as 2 to 6 hours earlier in many cases. Much property can be moved - or protected - and people evacuated in those 2 to 6 hours.

Use of Radio for Data Collection

As has been previously noted, dedicated telephone lines are expensive and if regular lines are used there is a basic time delay introduced by dialling times. In addition many of the gage locations, particularly river sites, are in remote areas where it would be very costly to extend dependable telephone lines to serve the gage. As a result many current data collection networks, particularly in remote areas, have made use of radio as the communications link. One of the newest radio systems in use by the Weather Bureau is a six-station network near Fairbanks, Alaska[4]. This is a wilderness area and radio is the only practical means of communication.

A basic shortcoming of radio is the relatively short distances that can be covered. The frequencies assigned to hydrologic activities in the U.S.A. limit transmissions to line of sight. The location of gages along river valleys makes the use of radio relays necessary: even over flat terrain, a relay is required about every 30 miles (48 kilometers). A radio system often requires about as many relays as sensors and both types of installations are of nearly equal cost.

If radio is being used for communications, a decision must be made on the required frequency of reports. If data are needed on an on-call basis, the radio transmitter at each sensor must operate continuously in order to pick up the command signal from the collection center asking for a report from that gage. This represents a power drain that presents difficulties when a power line is not available. The alternative is a clock at the sensor to turn on the radio and transmit a report at regular intervals. This system eliminates the possibility of obtaining special reports in an emergency. Clock trouble can complicate collection schedules, causing the report from one station to coincide with the report from another station. Scheduling reports from a large number of stations would be extremely difficult.

Use of Synchronous Satellite to Relay Data[5]

The most promising development in recent years is the use of a synchronous satellite to relay hydrologic data. Two such satellites, stationed at heights of about 23,000 miles (37,000 kilometers) above the equator could serve the entire U.S.A. and eliminate the need for the literally thousands of surface relays required for a complete radio data collection system. This does not eliminate the scheduling problem, just discussed, of how each station is to report. It has not yet been determined whether this system will utilize clocks to trigger each sensor or will be activated by a radio "command" signal. In any case the data being relayed by the satellite could be picked up directly by interested forecast offices with no delay for ground communication links.

The use of synchronous satellite to collect hydrologic data has already been tested successfully. Data were successfully collected over a two-year period from three ground sensors located hundreds of miles apart. Each sensor was polled in turn by command from the ground control station. No difficulty was encountered despite the distance covered by each signal with one exception. An attempt to receive the data directly from the satellite at our River Forecast Center in Fort Worth, Texas, was unsuccessful because the background noise in this urban area masked its relatively weak radio signal. It may be that antenna will have to be located away from busy city areas in order to operate effectively. In any case, a system such as this can reduce the time required to observe and collect river and rainfall data (A+B in Fig. 2) to an absolute minimum and make many valuable additional hours available for preparing for floods.

Satellites offer many other possibilities to the hydrologists in addition to their value as a communications relay[6]. Currently they are of the most use in the areal delineation of snow cover and ice fields, but many other uses are being investigated.

Use of Radar Data

The utility of radar data in river forecasting has been clearly demonstrated in recent years[7]. Radar signals are reflected by rain drops and the strength of the radar echo is roughly proportional to the rate of rainfall. This fact has been known for many years; but only recently have practical means of getting this information on a real time basis to the river forecaster been developed. A current experiment will attempt to assemble and process data from four radars with the objective of presenting integrated rainfall amounts for specific time periods for predetermined drainage areas to three forecast centers in a form that can be fed directly into a high speed digital computer. No new processes are required to accomplish this; the principles have already been thoroughly demonstrated and tested. Rather, the techniques for handling such a large amount of data are all that are unique in this operation.

The possibilities for speeding up the river forecasting process, as well as for making more accurate forecasts, through the use of radar data are tremendous. The time required for observing and collecting of rainfall data could be reduced by hours. When combined with the automation of river stage sensors, the forecaster has all the tools necessary to make several additional hours available for flood mitigation activities.

Use of Computers in Forecasting

In the processing of the basic hydrologic data and the preparation of the flood forecast (C in Fig. 2) certainly the most significant advance in recent years has been the application of computers to the forecast operation. Most conventional hydrologic forecasting techniques, when applied to larger river systems with several forecast points, involve considerable repetitive operations that make computers quite useful. In the U.S.A. where a typical forecasting center prepares forecasts for 100-200 points, high-speed digital computers are currently being utilized for forecasting. Tests of remote terminal computer installations appear quite promising and seems likely to be the eventual answer to the ever-growing demands of the river forecaster for larger computer storage capacity to enable him to use more complicated forecasting techniques, such as relatively sophisticated hydrological forecast models[8].

FORECAST DISSEMINATION

In the field of forecast dissemination (D in Fig. 2) one recent development has been the use of dedicated (single-use) line teletype circuits[9]. These circuits connect the forecast office with various important "users" as well as many of the radio, television and newspaper offices in a given state. This enables the forecaster, in a single operation, to transmit warnings into the offices of action agencies as well as to the mass news media (newspaper, radio, and television offices). When this is compared to the time and manpower required to complete the numerous individual phone calls previously required to achieve the same results, the saving in time is considerable. Use of teletype circuits for dissemination also produces the warning message in hard copy, making possible detection and immediate correction of errors in the message transmission.

The foregoing discussion clearly indicates that the time to produce a flood forecast after the flood producing rainfall has stopped (A+B+C+D in Fig. 2) could be reduced by hours using presently available information and hardware. It is a costly operation, but the average flood damage figure for the U.S.A. is now estimated at one billion dollars and only minor reductions in this total are necessary to justify such an investment.

A very special problem is the phenomena known as a "flash flood". This is a rather loosely defined term, but essentially it is applied to floods in which the water rises very rapidly and the flood crest occurs a relatively short time after the end of heavy rainfall. In Figure 2, we might arbitrarily call the event shown a flash flood if the "available time X" is less than six hours. In some cases it may only be a few minutes. Obviously only minor preparations can be made for a flash flood even when flood warnings are made under ideal circumstances. Warnings, when possible, are generally aimed primarily at saving lives although evacuation of even a few valuable items can represent appreciable savings. Often warnings do not contain forecasts for specific stages but are of a general nature. If possible, the magnitude of the current flood event is compared to an earlier flood as a guide to the severity of overflow expected.

Heavy rains which cause flash floods are generally the result of thunderstorms and usually affect only small areas. The reduction of the time required to produce flood forecasts (A+B+C+D in Fig. 2) becomes extremely critical. One solution has been the establishment of a flash-flood warning system handled by the local community to avoid communications delays in both the collection of data and the dissemination of forecasts. Rainfall and river data are all handled locally and the responsibility for the preparation and dissemination of warnings is also handled by a local flood warning representative. Simple forecast procedures provided by the Weather Bureau are used in order to minimize the forecast time required and because they are likely to be utilized by someone with little hydrologic background. Every effort is made by the Weather Bureau to supply the local representative with warnings of expected heavy rains based on meteorological forecasts and/or radar information.

In some very flashy cases, it is planned to make use of a special flash flood alarm. This alarm sounds a warning when water reaches some predetermined river level at a point upstream from the critical flood area. This device could be used as the only source of warning (such as sounding a siren) or to activate the reporting network of a local flash flood warning system.

COMPLICATIONS WHEN PRECIPITATION FALLS AS SNOW

There are, of course, many other combinations of events which must be considered in a discussion of flood warning times. If, for example, the flood producing precipitation assumed in Figure 2 had fallen as snow, the time to flood crest (X in Fig. 2) at town R might increase to days, weeks or even months. This is the situation which made Operation Foresight possible.

Precipitation falling as snow instead of rain creates many new problems for the flood forecaster. Although warnings are possible much further ahead, there is always the possibility of additional precipitation before the snow melts. Particularly critical is rain falling while snow melt is taking place. This combination can cause a much greater flood than would have been forecast on the basis of the snow or rainfall alone.

The Use of Quantitative Precipitation Forecasts

All of the prior discussion has been based on the assumption that the flood forecaster waited until the rainfall was actually "on the ground" before preparing flood forecasts. Of course, preliminary warnings based on partial storm totals can be prepared during the storm, but these only serve as minimum forecast values subject to modification upward as significant additional rain occurs.

River forecasters in the U.S.A. have had regular quantitative precipitation forecasts (QPF) available to them for many years. The accuracy of these predictions has steadily improved in recent years and they are of increasing usefulness to the forecaster. In general the forecasts of the maximum rainfall amounts for a given storm situation are quite good. A basic problem exists in forecasting the exact location of heavy rainfall centers geographically. The quantitative precipitation forecaster is dealing with a meteorological observing network that is fairly sparse and with meteorological systems that cover large areas. The river forecaster, on the other hand, works with river drainage areas that are relatively small in comparison. A good QPF may be in error geographically by a relatively small amount, but in river forecasting terms the precipitation may fall into a completely different river basin than the one where the heavy precipitation had been forecast.

Specific flood forecasts are very infrequently issued based entirely on quantitative rainfall forecasts. To do so would result in too many false warnings which would materially reduce the creditability of river forecasts based on observed precipitation and reduce the willi gness of people to make the necessary preparations. The primary usefullness of the QPF comes in alerting the river forecaster to potentially dangerous situations and allowing him to prepare for it. The false warning problem does not come into effect here, since the river forecaster is thoroughly aware of the probabilities. Knowledgeable representatives of other agencies are often alerted on the basis of the QPF since they too need to be prepared.

TIME ADVANTAGES AND DISADVANTAGES AT RIVER LOCATIONS DOWNSTREAM

Previous discussion has been concerned with the situation at town R, the upstream or headwater point. Obviously, in the simple storm assumed for discussion, any actions that increase warning times for town R will add approximately the same increment to the warning time (F) at town S. This time advantage continues to grow larger as one moves downstream. The complication is, of course, that as the warning time increases so does the chance that additional rain will occur that can affect flood crests as flood waves move downstream. Whereas the flood forecaster can tell the flood fighter that rain already on the ground will produce a crest of a certain magnitude at a certain time this is really a minimum forecast. Additional rain can increase the crest stage with much less warning times, especially downstream, then would be available for the simple storm used in the example. This possibility complicates the job of preparing for a flood. Additional rain may negate the effort to build temporary levees by raising river levels to heights for which no protection is possible. In this respect, the use of temporary protection measures is somewhat a gamble. Evacuation of property, however, is effective as long as it has been moved to a location not subject to flooding.

SUMMARY

It is not possible to build permanent water control structures to protect everyone living on, or all the property located on, flood plains. In many areas people must learn to live with floods when they occur and for them a warning of impending flooding is most valuable. Every hour or additional warning time may represent countless savings in property protected from the floods or moved out of the path of the flood. As a result every possible means of speeding up the distribution of flood warnings needs to be explored and implemented if it is practical. Automation of collection of necessary precipitation and river data using telephone or radio for the communications link offers the most obvious time advantage. The potential use of a synchronous satellite for a communications relay makes radio a particularly desirable choice. The use of radar to evaluate areal precipitation values and the use of computers to speed the forecasting operation provide additional savings in time in the forecasting process with resultant increases in time available for flood preparations.

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CCMS No. 2

ELEMENTS OF RIVER FORECASTING

Marshall M. Richards
Joseph A. Strahl
(United States)

The flow of a river fluctuates through a considerable range on an annual basis. It is characterized by rises, due to runoff from rainfall and snowmelt, followed by gradually receding flow. Flood forecasts are primarily concerned with predicting the time and height of stages caused by peak flows. Forecasts are also made for the stages expected at various times during the period of risings and falling stream levels. In recent years, the trend has been toward more detailed forecasts of continuous flow. Water supply forecasts predict the total flow for an entire water year. These forecasts are feasible in mountainous areas where water is stored in snowpacks during the winter and released into the streams when snowmelt occurs.

This paper is chiefly concerned with forecasting storm hydrographs with emphasis on the crests. There are three major steps to forecasting the rise that results from a rainstorm or period of heavy snowmelt:

(1) Estimating the volume of water that will run directly off the land surface into the stream. This step utilizes the rainfall-runoff relation and computation of rate of snowmelt.

(2) Forecasting the distribution of this volume of water with time as it passes a forecast point. The unitgraph is usually used for this purpose.

(3) Forecasting the change in shape of the floodwave as it moves downstream. This is known as streamflow routing.

A simple treatment of these steps is provided in "Elements of River Forecasting", as an introduction into the problems of developing river forecast procedures and applying these procedures to the preparation of forecasts.

The full text of the presentation published as ESSA Technical Memorandum WBTM Hydro 9 in March 1969 may be obtained from the US Department of Commerce, Environmental Sciences Services Administration, Washington D.C.

A VALUABLE PRECEDENT

By Brig. Gen. Robert M. Tarbox

Many communities, having escaped damage, have already forgotten this year's spring floods. Others are not so fortunate. They are still in various stages of recovery. They are also painfully aware of future flood risks. They appreciate that the flood threat is recurrent, that the next cycle of high water may force thousands from their homes, inundate railways and highways, kill wildlife, disrupt business activities, destroy bridges, cut communication lines and wreak untold personal losses. Minimizing these damages is an assignment of crucial importance.

Communities in river basins subjected to snowmelt floods face double jeopardy. Heavy rains alone can bring floods, and when above normal snow accumulates, they also face serious snowmelt flooding during the spring runoff period.

This was one of the years when the snowpack was deep and the water content higher than normal. To aggravate the problem, the first snow fell on rain-soaked frozen ground, preventing any soil absorption when the melt came. Surface runoff was the only course open, suddenly in one devastating rush or intermittently over a period of weeks from a series of short thaws and freezes.

This is an account of the activities prior to the actual start of the flood that led to the unprecedented use of funds on measures to prevent damages. During these operations, the St. Paul and Rock Island Districts of the Corps of Engineers, North Central Division, spent about $11.9 million which contributed to the prevention of about $106 million in flood damages, as well as an inestimable amount of heartbreak and anguish.

Twenty-six States were in the snowmelt path this year, and near-record floods were a distinct possibility. The St. Paul and Rock Island District Engineers started preparing for it early. In January and February they conducted numerous conferences with local communities to advise them of the threat and to assist them in preparing to meet it. However, it was when President Nixon gave the matter his personal attention that a stepped-up floodfighting pattern was established to set a precedent for extensive use in future years - particularly in areas where conditions such as heavy snowpack give early danger signals.

In a letter dated 1st March, several weeks before the first significant snowmelt, Brig. Gen. G.A. Lincoln, Director of Emergency Preparedness, Executive Office of the President, notified Secretary of the Army Stanley R. Resor that "the President has directed that all feasible steps within the authorities of the Federal agencies be taken to prepare for floods which threaten to occur in various parts of the country because of the unusual snowpack conditions which now exist".

Special reference was made to authorities of Lt. Gen. William F. Cassidy, Chief of Engineers, granted by the 84th Congress under Public Law 99, for preparations and operations during flood emergencies. Previous use of the authority had been mostly for operations during floods, but President Nixon urged "aggressive use of these authorities under present conditions". Under that directive, Secretary Resor and General Cassidy made Corps funds, personnel, equipment, supplies and other resources available for full-scale preventive measures.

Under a program which the Office of Emergency Preparedness named "Operation Foresight", the Corps was a principal agency representing the Federal Government, especially during pre-flood stages. Endangered communities welcomed the offered assistance, and their response along with maximum co-operation of local, State and Federal agencies brought quick results. Community actions were vigorous, early and positive. They provided rights-of-way, labor and other community resources. A number of communities worked around the clock building dikes and making other preparations. Students, businessmen, public and independent organizations all pitched in to help. They looked to the Corps for expertise, supplies and equipment.

Never before had so much major equipment for flood-fighting been mobilized on such short notice. Never before had so many communities started emergency planning and action so far in advance of a flood threat. Never before had emergency preparations been so thorough.

One local official pointed out that in past floods, people have suffered excessive damage because "warning of impending danger did not come nearly so early".

This year the warning came early enough to create a calm alert in all the flood-threatened river basins. News media helped create public understanding of the problem and what could be done about it. A Corps film, used extensively by TVsstations and at group meetings, brought to many communities a vivid recall of past flood damage. The documentary account, showing part of the $100 million damage in the record 1965 flood in the Upper Mississippi River Basin, placed the flood threat in realistic perspective.

This year's collection and analysis of snowpack conditions were more complete than for any previous flood threat. Both the US Weather Bureau and the Corps informed the public of what to expect under different thawing conditions.

Communities from coast to coast requested and received assistance. The biggest challenge for Operation Foresight, however, was in the Dakotas, Minnesota, Wisconsin, Iowa, Illinois and Missouri where the Corps' North Central Division has flood protection responsibilities in the basins of the Upper Mississippi River, the Red River of the North, and the Souris River.

By the end of January the District Engineers had begun their surveys to determine the water content of the snow. It soon became apparent that serious flooding was a strong possibility. The water content of the snow cover was extremely high, natural ponding areas were generally full and winter streamflows were ranging from two to two and a half times normal.

Meanwhile, at the Chief of Engineers' headquarters in Washington, D.C., a computer print-out named the Corps' most experienced flood experts. From that list the Corps assigned some 260 civilian and military engineers and other staff personnel from 24 Districts to help out in the North Central Division. The first arrivals assisted in checking out known danger areas and inspecting soundness of existing levees and flood control structures throughout the river basins.

In early March at Sioux Falls, representatives of most of the States in the Missouri and Upper Mississippi River Basins met with Office of Emergency Preparedness and Corps of Engineers representatives to co-ordinate plans and actions. The Corps assigned liaison personnel to State capitals to keep activities co-ordinated with the extensive preparations by both public and private organizations.

After the Sioux Falls meeting our Districts went into high gear. Within less than a week we had reached agreements with the States in the Upper Mississippi Basin on the terms and extent of Federal assistance. Our people went to nearly 200 communities to discuss preventive measures and explain the various types of assistance the Corps could render. They explained that assistance would be employed in a Federal-State-community relationship, with the communities taking the initiative. Communities agreed to adopt feasible protection plans and to provide rights-of-way, labor and source of levee materials.

As additional steps, we had already stockpiled equipment and supplies. The American Radio League established an emergency communications backup net. We reviewed and renewed our contracts with the American General Contractors and assured ourselves of their readiness to respond when needed. We conducted in-house flood training. We revised and distributed manuals and other printed materials reflecting our latest, most effective floodfighting techniques.

Innovation and ingenuity strengthened age-old floodfighting tactics. The Corps used 12 and 16 inch diameter irrigation pumps in the floodfight. Farm tractors provided the power source. The Corps contracted crop duster planes to dust lake and river ice with dark inert material. This practice, tried previously on ice jams in 1966, results in the sun's heat being held and absorbed, accelerating ice melt and making breakup easier by weakening the ice sheets. Ice blasters used primacord, dynamite and a mixture of fuel oil and ammonium nitrate, and they experimented with varied ignition delays to set off explosions in a series.

The Corps experimented with plastic sandbags. The cost was about half that of burlap sandbags; some were satisfactory while others were not. Spray adhesives had to be used to hold the stacked bags together.

Some communities saw urethane foam, a semi-rigid type of plastic sprayed on their sand dikes. A research team evaluated this new product as a slope and seepage control material. It proved remarkably resistant to puncture type failure.

By the time the highest river crests arrived the Districts had cleared channels, reinforced levees and assisted 291 communities and 29 levee Districts in constructing over 150 miles of emergency levees. We had augmented local efforts with 237 equipment rental contracts involving 3,500 pieces of equipment, and we had furnished over $760,000 worth of supplies, more than 150 emergency pumps, and nearly one million feet of polyethylene plastic sheeting.

What really distinguished this operation from preceding ones was the authority to use Public Law 99 funds early - to prevent damage. It made sense.

For example at Big Island, Illinois, where 1965 flooding caused over $300,000 in damages to 150 homes and a grade school, a total of 1.2 miles in emergency levees contained the flood waters this year. The cost was $103,000 for equipment rental. The new levees will be incorporated into the community's permanent protection plan.

At Rock Island, Illinois, the 1965 flood damages exceeded $3 million, but this year the early action by local people prevented most of the damage. They had emergency protection well underway at the time the Corps initiated Operation Foresight, assisting them with a $76,000 levee construction contract to tie-in an emergency dike to another temporary dike built by a steel company there. In addition, the Corps issued 45,000 sandbags and 3,800 feet of polyethylene for use by the Rock Island community.

The western section of Davenport, Iowa, suffered severe damages in 1965 when the Blackhawk Creek levee breached, flooding a residential and industrial complex. Backwater and debris also damaged downtown businesses. Total loss exceeded $3.8 million. This year an Operation Foresight levee of 3,750 feet for a cost of $111,000 kept the area secure. Most of the levees were left in place after the floodwater subsided.

At East Moline, Illinois, the previous flood displaced 2,500 people and damaged residential, commercial and heavy industrial properties in excess of $1.5 million. This year emergency work prevented similar damages. Two reaches totaling 4,100 feet for a cost of $89,000 will be encompassed in the city's permanent protection system. The Corps also issued 55,000 sandbags and 4,500 feet of plastic sheeting to the city.

At Henderson, Minnesota, which has a population of about 1,000, the damages four years ago amounted to about $650,000, and 95 families had to be evacuated. The city knew a flood was coming, but it did not have resources to take adequate protective measures. This year $130,000 of Operation Foresight funds built an emergency levee that prevented at least $300,000 in damages. Most of the levee will remain in place as part of a permanent system.

In all communities taking preventive measures, success came from the total effort of people and their organizations working together. The Granite Falls, Minnesota, Tribune in an expression of appreciation described it this way: "Actually, it was the youngsters and their boundless energy and high spirits that saved Granite Falls from flood destruction. No community could ever feel more proud of the young people than does Granite Falls.

"Our deep appreciation and sincere thanks go to the adults from a wide area who heard that help was needed. Without their help the floodfight would have failed.

"Our thanks to the members of the National Guard who were called in to assist. The presence of the Guardsmen helped, local police and civil defense workers handle what could have been a major traffic problem. The Guard also lent its aid to the dike construction.

"Our thanks and appreciation must go to Army Corps of Engineers for their skill and knowledge. They stayed right on the job when most of this city's residents scoffed at their extensive flood preparations. We learned that the engineers knew what they were talking about.

"In its message of thanks, the Tribune will not name any one person in particular.

"Just let us say that we never before felt so humble and proud at the same time as last weekend when Granite Falls fought our beloved Minnesota River in its most furious mood and won".

That emergency measures paid off is beyond question. The total amount of prevented damages in all the States that received Operation Foresight assistance is estimated at $250 million for a cost to the Federal Government of about $18 million and no more than that for combined State and local expenditures.

Exact amounts are subject to refinement, but estimates were based on a number of firm references. Estimators knew the approximate areas that would have been flooded had emergency measures not been completed. They had an inventory of property values in areas subject to flooding, and well documented value losses for similar flood-damaged property. Their reference material also included actual records of contract costs for evacuation and cleanup of past floods.

Their preliminary estimates showed the greatest savings from Operation Foresight were in Minnesota where over $57 million in damages were prevented by the expenditure of $5.2 million. This compared with $8.7 million in prevented damages in Iowa where the Federal cost amounted to less than $2.4 million.

In North Dakota, 24 communities received assistance amounting to $1.9 million, preventing damages of $18.6 million. For $1.5 million in 26 Illinois communities, Operation Foresight helped prevent an estimated $4.6 million in damages. Wisconsin had 50 communities that received $770,000 worth of assistance in the program, preventing damages estimated at $6.8 million.

Despite all the emergency preventive measures, however, sections of some places were beyond saving. Minot, North Dakota, for instance had its worst flood since 1904. Over 12,000 people were forced from their homes, and even though some $9 million in damages were prevented there by temporary dikes and other measures, the loss still exceeded $10 million.

In other areas of North Dakota and in South Dakota, Minnesota, Iowa and Wisconsin an additional 10,000 people left their homes. At one place on the Red River of the North, a floodwater lake five to seven miles wide formed along the river.

In effect, emergency measures to supplement and support local and State actions are certainly better than waiting for the flood to occur before we react. But they are hurried solutions that provide limited benefits.

Many localities in our flood-prone area need more than hurried solutions. They need better permanent type protection against recurring flood threats. One such case centers on the risk for the Twin Cities metropolitan area. Two rivers join there - the Mississippi and the Minnesota. Snowmelt runoff through the drainage systems of these rivers brought, in addition to this year's flood, abnormally high amounts of flood water in 1951, 1952 and 1965.

In contrast, while crests were dangerously high this year at the Twin Cities and the Big Sioux was on its worst rampage since 1881, the mighty Missouri flowed gently to the sea, regulated by upstream reservoirs.

In Wisconsin the dry, safe community of Spring Valley on the Eau Galle River was testimony of a smaller scale permanent type protection. During the record flood of 1965 the community of some 1,000 people had seven feet of water in their streets. This year a short distance upstream, rising 122 feet above the valley floor, a new dam held back the flood waters.

Flooded and endangered communities this year were aware of localities throughout the Nation where permanent flood control systems afford varying degrees of protection. Many of these places are where the Corps, in co-operation with State and local agencies, has already placed in service over 300 reservoirs, 10,000 miles of levees and flood walls, and 8,000 miles of improved channels. The total program to date has already prevented damages that would amount to more than three times the investment in construction.

On the other hand, economic or other reasons have precluded construction of permanent type protective works in some river basins. And many of these communities with little or no permanent protection still face formidable flood control problems. They must resort to temporary measures when floods threaten. Yet, as a result of this year's experience, their future flood emergency preparations, when early warning is possible, will be better organized and more effective. Operation Foresight has brought them a new floodfighting pattern.

CCMS No. 2

EMERGENCY FLOOD FIGHTING OPERATIONS

by Donald G. Eddy (United States)

The field mechanism for managing Federal assistance in Presidentially declared major disasters is simple and takes top priority in the eight regional offices of the Office of Emergency Preparedness when the need arises.

The Office of Emergency Preparedness is responsible under laws and Presidential Executive Orders for direction and co-ordination of Federal disaster aid activities. OEP administers the President's Disaster Relief Fund (Public Law 81-875) and co-ordinates the assistance energies of the other Federal departments and agencies. The co-ordination by OEP in no way relieves any department or agency of any function, duty, or responsibility vested in it by any provision of law.

Effective directing and co-ordinating are twin keys involving over twenty agencies with more than 100 regular programs available for disaster use. OEP's objective is to ensure that a comprehensive and efficient response to disasters results.

The responsibility for administering the Federal disaster programs has been redelegated from the Director, Office of Emergency Preparedness, to the OEP Regional Director. Each Regional Director has disaster assistance responsibility for several States in a particular section of the country. OEP Regional personnel maintain continuous liaison with all Federal agencies and all key State agencies having disaster responsibilities in the States of its region. A directory of top officials with disaster responsibilities, Federal and State, is maintained by the OEP region.

The States in OEP's Midwestern Region 6, located in Denver, Colorado, have annual flooding both from snowmelt and from heavy seasonal rainfall, thus some rise in river level and spillage into the flood plain can be expected on a recurring basis. When excessive precipitation is present, potentially disastrous situations for both individuals and their property can result. The initial alert or identification of a potentially serious threat of flooding could come from any of a number of sources: ESSA-Weather Bureau, Corps of Engineers, Federal Aviation Agency, States, wire services, etc. Once the situation is identified, phone calls go out from the OEP Regional Office immediately to several places; the Governor's office, State disaster office, and Federal agencies, advising them of the threatening situation so that they may take appropriate preparedness actions. The Disaster Assistance Division in OEP National Office is also advised by the region of actions taken.

A highly successful response has been developed to meet disaster threats. Federal, State, and local authorities initiate co-ordinated actions to mitigate or eliminate the damaging effects of the potential disaster. Meetings are called to discuss the situation and determine particular emergency preparedness measures that could and should be taken to prepare for the potential flood threat. Governors or their representatives, the above-named agencies, together with the Department of Defense, Interior, Housing and Urban Development, Transportation, Health, Education, and Welfare, Interstate Commerce Commission, the Red Cross and State counterpart agencies discuss the situation in specific terms as to what each can contribute to the operation. Where threats exist on the Red and Souris Rivers, information is also co-ordinated with OEP's Canadian counterpart, the Emergency Measures Organization.

Agencies such as the US Weather Bureau and its River Forecast Center, US Army Corps of Engineers, US Department of Agriculture, US Geological Survey, Bureau of Reclamation and OEP are continually monitoring the changing conditions during potential flood periods, and are prepared to initiate quick reactions to new situations.

Depending upon the magnitude of the situation, co-ordination of Federal response may be from the OEP Regional Office location in an early build-up phase with necessary on-site visits, to the establishment of a full-scale field office at the disaster site. More and more emphasis is being placed on on-site management of disaster operations.

The abnormally heavy accumulation of snow during the winter of 1968-69 presented a serious flood threat to eight Midwestern States covered by two OEP Regions. ESSA-Weather Bureau issued warnings early in February of the real potential for disastrous floods. President Nixon expressed his concern on 1st March and on the same day OEP Director George A. Lincoln urged the Corps of Engineers to aggressively utilize available authorities to do channel clearing and repairing or constructing new levee sections where urgently needed.

One of the eight States, North Dakota, was particularly hard hit. This experience provides an illustration of the close meshing of a Federal/regional response to a major disaster.

While the mechanism is simple, the need for central control, direction, and co-ordination cannot be overemphasized. For example, the Corps of Engineers has been referred to above in singular terms; however, this is not the case as there are two major river systems, the Mississippi and the Missouri, flowing through North Dakota. North Central Division's

(Corps of Engineers) St. Paul District has responsibility for the Mississippi and the Omaha Division's (Corps of Engineers) Omaha District has Missouri River responsibilities.

As Federal disaster assistance is supplemental to State and local effort, joint meetings with OEP, Corps of Engineers, and ESSA-Weather Bureau had to be arranged with State and local officials to advise them of the potentially serious flood situation and of the aid that was available. This was accomplished in mid-March.

The Corps of Engineers, working under their own statutory authorities, assisted in preparations as communities requested their aid and agreed to co-operate to the maximum extent with their own resources. The Corps, Omaha and St. Paul Districts, by daily telegram kept OEP and other interested organizations fully informed of their activities, progress and problems.

Other agencies were requested to take whatever measures they could to reduce effects of possible flooding. The Interstate Commerce Commission's Chicago office was requested to assist grain shippers locate rail cars for movement of their commodities out of the areas most likely to flood. The US Coast Guard's Second District deployed crews and equipment for potential search and rescue operations. Other Federal agencies were contributing to the readiness of North Dakota. OEP Region 4, located in Battle Creek, Michigan, and OEP Region 6 were in continuous communication as the Red River of the North is the common boundary between OEP Region 6 State North Dakota and Region 4 State Minnesota.

The temperatures during March were favourable for a gradual runoff with daytime temperatures being in the low 40s and night temperatures in the low 30s. However, the nearer April drew, the greater was the possibility of higher temperatures and quicker melt. With high temperatures the snow would rapidly become water and the flooding potential would become more serious.

On the last day of March temperatures soared to the 60s and stayed there fore the next week. Although the completed preparations did protect property valued at many times the cost of preparations, serious flooding did occur.

In consultation with North Dakota State officials, advance plans had been made for setting up field offices and co-ordination meetings. It was agreed that the principal field office would be in the are requiring most assistance.

Although the first serious flooding did not occur until 10th April, based on flood crest prediction, Minot had already been selected as the principal OEP field office site. Office space was secured in the Minot National Guard Armory. The General Services Administration provided telephone access to their FTS (Federal telecommunications service). Federal agency offices anywhere in the country could then be reached as easily as though they were on a local call basis.

The President declared a major disaster for North Dakota on 18th April thus triggering the full range of Federal assistance. Assignments for damage surveys, in order to pinpoint specific locations and categories of assistance, were made to the following:

Bureau of Public Roads	Streets, roads, bridges and storm sewers
Fifth US Army and Minot Air Force Base	Assistance to City of Minot
Corps of Engineers	Debris clearance, protective measures, dikes, levees, and drainage facilities
Housing and Urban Development	Temporary housing
Federal Water Quality Administration	Sewage plants and sanitary sewers
Soil Conservation Service	Drainage and irrigation districts
Health, Education and Welfare	Health and sanitary protection and water facilities
General Services Administration	Public buildings and related equipment, except schools
Office of Education	HEW was advised of school damage as the Office of Education, within that department, has responsibility for disaster assistance for schools

Each of these agencies has State counterpart agencies that together comprised effective Federal/State response teams. Federal and State engineers met with local officials to determine damage and estimated cost of disaster-related remedial assistance and make initial plans for recovery.

Close liaison was maintained with the American National Red Cross and Salvation Army. These organizations were primarily concerned with mass feeding and lodging of the flood's victims. Their activities were co-ordinated with Federal and State agency longer ranged and more permanent assistance measures.

Daily progress of the Federal/State response teams making damage surveys was continuously co-ordinated to assure the securing of timely and adequate assistance. Funds were advanced on the basis of the surveys to assist the State and communities in their recovery efforts.

A series of five meetings was arranged around the State to discuss and publicize the assistance available and how public officials and disaster victims could make application for the assistance. Bismarck, Fargo, Grand Forks, Jamestown and Minot were selected as centers for the meetings.

In addition to those agencies that instituted programs via a direct assignment from OEP, a number of agencies such as Small Business Administration, Farmers Home Administration, Veterans Administration, Federal Housing Administration, Internal Revenue Service, and American National Red Cross initiated other assistance programs for individuals. Each agency was requested to provide personnel to describe the assistance available at each of the five meetings and also to provide information as to location of their field assistance offices and their hours of operation. Government - Federal, State and local - working closely together responded to the needs of the citizens of North Dakota.

The direct support and interest of the Chief Executive are essential for successful response and operation of an effective disaster assistance program. At the national level the President has indicated to the various departments and agencies his concerns and desires as well as the importance in which he holds the Federal disaster assistance program. Agency heads have conveyed this throughout their organizations. At State level, the Governor's direct involvement reflects his interest in an effective State agency response. Mayors and County Commissioners are responsible at local levels for those activities.

While all agencies have full-time on-going programs, priority effort is given to meeting assigned responsibilities in times of disaster. This dual rôle eliminates the need for a large-scale standby disaster assistance organization which would only be used to meet emergency disaster situations. In large disaster situations this could mean the utilization of several thousand Federal agency personnel. The total of all OEP disaster assistance personnel, National and in the eight regions, is less than 80 people including secretaries.

Each OEP Region has the responsibility for development of an effective disaster response. Predisaster understanding between Federal officials and their State counterparts is essential. Organization arrangements and measures for response are refined in non-disaster periods. Annual workshops and training sessions are conducted in each State with all Federal agencies having disaster assistance responsibilities. These annual events provide a forum for the exchange of information or preventative and remedial steps that may be taken to ensure effective emergency response. They also provide the opportunity to discuss mutual problems and organizational arrangements necessary to respond effectively to an emergency situation.

All government officials should be well acquainted with basic disaster assistance and their responsibilities in order to reduce confusion and unnecessary concern during a disaster. Citizens instinctively turn to government for assistance and factual information during crisis periods. They need and expect to get information and assistance from their public officials. Therefore, in order to reduce frustration, all possible assistance should be offered through existing governments. Any one official will not know every program nor would he be expected to, but he should be able to identify where specific disaster-related information is available.

The slow developing character of the North Dakota flood permitted time for significant preparations. Disasters such as tornadoes and earthquakes may have only several hours or less warning time. Nevertheless, government must be prepared to respond effectively regardless of the length of warning time.

On many occasions the threat does not develop into a disaster situation but preparations still must be taken. During this past winter, 1969-70, the snowpack was 200 per cent of normal in the Colorado mountains, presenting an extremely serious flood threat. OEP Region 6 called two meetings, one in March and the other in May to assess and discuss the situation. Federal agencies invited to participate were the US Weather Bureau, Bureau of Reclamation, Bureau of Public Roads, Corps of Engineers, and US Geological Survey. Colorado State agencies, such as State Highway Department, Highway Patrol, Department of Health, Water Resources, Water Conservation, and the State Disaster Co-ordinator were invited as was the Denver Water Board. The discussions resulted in lowering of reservoir levels, increased monitoring so that reservoir levels could be manipulated if flood situations did develop. Also, the Highway Department surveyed situations at bridge sites to reduce possibility of damming caused by debris buildup. This time weather conditions were favorable and a gradual melt resulted so there was no serious flooding.

Federal, State and local officials were prepared to respond had a worsening situation developed. Potential disaster situations such as this could and at times do present problems and criticism. Preparations require use of manpower and expenditure of funds. When the disaster situation fails to develop, hindsight is more acute than foresight, and frequently criticism for the expending of funds for unnecessary preparedness activities results. This is a risk that responsible officials must accept because failure to initiate preparedness actions could have devastating results if the disaster situation actually develops.

A great many things have been learned about administering disaster assistance in an expedient manner from actual experience. Improvements have been made in all phases of preparedness from planning, prevention, warning and communications to response and assistance. However, in a program such as this there are always ways to improve further. One of OEP's main responsibilities is to insure that the lessons learned from past disasters are incorporated into the response to subsequent disasters.

Communications are always an important element in coping with disaster situations. Arrangements with General Services Administration and the Department of Defense are made pre-emergency to assure availability of emergency communications. Equipment may be mobile or of the type requiring installation once field office is selected. Equipment is usually not installed pre-emergency because we are unable to predict with any degree of accuracy where Mother Nature will vent her fury.

Availability and sources of aid should be accurately identified as soon as possible as should the necessary conditions under which it is obtained. Many States have highly restricted emergency funds which are inadequate to meet most disaster situations, particularly those of a magnitude which do not qualify for a Presidential declaration. States are being encouraged to establish funds and programs to meet this need.

The necessity for prior consultation and understanding between Federal and State counterpart officials cannot be overemphasized. Personal acquaintance with your counterparts almost guarantees more effective co-operation. The attitude and commitment of key officials is reflected through their staffs. A positive and co-operative climate is essential and can be developed through predisaster activities and strengthened by experience.

A program for effective utilization of volunteer assistance is essential. The desire to help is greatly appreciated but many times the number and type of volunteer places a severe strain on government's ability to utilize them. They may range from a willing body with no skills to a tradesman with all essential equipment. Some will be completely self-sufficient, others will expect food and lodging. Gifts from the general public of food and clothing sometimes cause more problems in the disaster area than they alleviate. Generally, a gift of money to the Red Cross for expenditure in the disaster area is the most effective method of disaster assistance.

Comprehensive programs of flood plain zoning and management are extremely important to effect longer-range reduction of flood-caused damage, meaningful zoning, primarily a responsibility of local governments, is extremely difficult to enact and enforce for many reasons, economic, political and social. General apathy and unwillingness to spend money to prepare for an event that may happen also contribute to the difficulty of instituting such programs.

Construction of certain facilities such as levees, dikes, dams and channels aid materially in reducing the effects of excess water. The main stem of the Missouri River is an excellent example of flood control by use of an extensive system of dams. North Dakota experienced very little difficulty from the Missouri River itself. Zoning and construction of flood control facilities require strong citizen support. People have to become involved and believe that these measures are for their common good. Too often interest and support fade as the water subsides.

"One-stop" service centers have proved very effective in providing emergency communications and assistance to individuals in disaster areas. All agencies having individual assistance programs are represented in these centers, thus, the individual can secure available aid by visiting one location rather than going to many scattered ones trying to secure appropriate assistance.

In the Midwest many consider the beginning of the spring flood season to be 15th March. At this time every year, government, at all levels must be prepared to react to this possibility. Special instructions on individual preparedness measures should be carried by the press, radio and T.V. An annual "Flood Preparedness Day", might be suggested to assure attaining a greater readiness. Even if the flood or other disaster does not occur, all concerned still have the satisfying feeling of having been prepared.

MODEL FIELD ORGANIZATION TO RESPOND TO NATURAL DISASTERS

by the Field Operations Office, Office of
Emergency Preparedness (United States).

I. Introduction

Natural disasters of various types are a continuing and ever increasing problem in the United States. While nature vents her fury in various ways, close to three-fourths of all major disasters declared by the President since 1950 have involved destruction caused by water. Throughout these past twenty years, Federal disaster assistance has been predicated upon the promise that it is supplemental to that aid provided by State and local governments. Because of the propensity of individuals to seek homes near bodies of water, it is anticipated that destruction caused by floods will continue to increase. The effects of a severe disaster in a highly populated area can be extremely devastating.

The Office of Emergency Preparedness has been delegated by the President the responsibility to co-ordinate the disaster assistance efforts of approximately 20 Federal agencies who administer in excess of 100 disaster assistance programs. Therefore, the OEP developed and instituted at the site of each major disaster an organization designed to manage centrally all aspects of disaster assistance. The key management positions in this field disaster organization are assumed by OEP officers stationed in one of the eight OEP regional offices: the regional office jurisdiction within the State where the disaster occurs assumes central responsibility.

Each OEP regional office contains about six professional staff members. For this reason, the bulk of a disaster field organization is comprised of officials from other Federal agencies. But all Federal officials operating in a disaster area act under the direction of the OEP Regional Director, who is appointed by the President when he makes a major disaster declaration. The Federal Co-ordinating Officer also works closely with the State Co-ordinating Officer appointed by the Governor who has management responsibility for State and local efforts.

II. Background

The occurrence of a natural disaster requires the swift implementation of a comprehensive management organization at the scene to direct the disaster assistance efforts. Each disaster has its own unique characteristics. Therefore, the response organization must be inherently flexible to respond to the unusual. This paper outlines the organization for emergency operations that the United States implements in serious disaster situations.

Successful emergency operations depend on aggressive and co-ordinated leadership. Preparedness activities at all levels of government must be continually upgraded, and increased emphasis must be given to co-ordinated planning. This planning stresses the importance of multi-organizational, response to each disaster situation. To achieve this, responsibility in specific areas is predelegated at both the Federal and State levels and uniform standards are developed. Follow-up preparedness and training exercises are held periodically to provide for self evaluation on the state of preparedness and to detect noticeable deficiencies. Prevention measures are stressed and implemented whenever possible to prevent damage and loss of life.

A national plan for disasters insures the implementation of this philosophy. This plan, developed at the national level, outlines the organization and procedures required to provide disaster assistance in the United States. Specific disaster area needs included are:

- Warning and Evacuation (as appropriate)
- Search and rescue
- Public Safety
- Health and Medical
- Food
- Welfare
- Debris Clearance
- Telecommunications
- Transportation
- Utilities

Interagency relationships and responsibilities must be clearly defined in each of these areas. Also, interfaces among the disaster assistance agencies and organizations at the Federal and State levels must be understood.

The Office of Emergency Preparedness Regional Directors, in co-ordination with their Federal counterparts and State officials, have developed a detailed plan for each State in their Region. These are flexible and consider the possibility of multi-State and multi-Regional disaster occurrences. Specific requirements for each area of disaster assistance have been ascertained for every State. Based upon these, requirements are outlined for State and Federal agencies.

The following matrix of potential severities and warning situations is the planning basis:

	No Warning	Warning (minimum preparation)	Warning (significant preparation)
Minor			
Moderate			
Massive			

From this, it is obvious that the worst possible case would be a massive disaster which strikes with no warning, such as a severe earthquake. Preparedness must be designed to respond to this "worst possible case"; planning assumptions cover the whole range of possibilities, however.

Because massive disasters present unique problems for Federal disaster assistance, a model field organization has been developed for implementation in these circumstances. But each different situation will dictate the needs and priorities of each disaster. The important requirement is that the Federal Co-ordinating Officer must respond to emergency situations without delay.

Organization

The model field disaster organization developed for use in massive disaster situations functions in support of the Federal Co-ordinating Officer, who has overall responsibility for managing and directing the Federal assistance effort. It provides for:

1. clearcut and unambiguous delegation of responsibility for all operations;

2. co-ordination of and among independent operations, especially as they compete for priority in the allocation of scarce services and resources;

3. co-ordination within operations, especially where different phases are handled by separate organizations;

4. co-ordination of all Federal activities with those of the affected State(s);

5. adequate support and administrative services to all operating elements; and,

6. timely and accurate information, both for decision-making and public dissemination.

The resources required in virtually all disasters are food, shelter, health and medical services, other welfare services (e.g. clothing), telecommunications, transportation and utilities. In addition, debris clearance, restoration of public facilities, and search and rescue must be accomplished. The EMERGENCY OPERATIONS OFFICE, headed by the Federal Co-ordinating Officer, directs and co-ordinates these activities.

During the emergency period, survival, rather than recovery, has first priority. Actions must be taken rapidly and often under hardship conditions. Lacking decision-making information, and to insure the preservation of life and property, efficiency frequently must give way to expediency. Recovery assistance - both public and private - is of secondary importance during this period. Nevertheless it must be addressed.

The Federal Government has a variety of programs which are designed to help both political subdivisions and individuals. Very soon after the initial trauma of the disaster, victims begin to search for ways to regain some semblance of their pre-disaster lives. Efforts to assist them must begin early but cannot interfere with the emergency operations. As critical needs are met, emphasis can shift to these recovery efforts.

The PUBLIC ASSISTANCE DIVISION (of the Emergency Operations Office) is responsible for working with political subdivisions in determining and obtaining the Federal assistance which they require. Parallel to it is the INDIVIDUAL ASSISTANCE DIVISION, responsible for disaster victims to determine and obtain the Federal assistance which they need.

To preclude conflict between the categories of assistance and to provide better for the unique operational requirements associated with each, the operations have been separated in the model field disaster organization. Each dividion reports to the Federal Co-ordinating Officer. Predelegation of responsibility for key functions permits the Federal Co-ordinating Officer to dedicate more time to direct liaison with the Governor(s) of the affected State(s) and to insuring close co-ordination of all Federal and State activities.

In addition to the key operational elements described, the model field disaster organization provides for support services: INTELLIGENCE, PUBLIC INFORMATION, CIVIL RIGHTS COMPLIANCE, AND ADMINISTRATIVE SERVICES. Finally, recognizing the unique capabilities of the military establishment for providing a broad spectrum of services, while acknowledging that primary responsibility for providing assistance following a disaster rests with civilian agencies of the Federal Government, the model field disaster organization calls for a SENIOR MILITARY ADVISOR to the Federal Co-ordinating Officer. Of great importance is the STATE CO-ORDINATING OFFICER, who directs the State assistance efforts and works with the Federal Co-ordinating Officer in all matters.

Federal Co-ordinating Officer

The Federal Co-ordinating Officer is appointed by the President. In most cases, he will be the OEP Regional Director for the Region in which the disaster strikes. The Federal Co-ordinating Officer has overall responsibility for the disaster assistance efforts.

The Federal Co-ordinating Officer:

1. co-ordinates and gives broad direction to Federal agencies providing assistance in the disaster area through the Emergency Operations Office;

2. co-ordinates and effects liaison with the Governor and his authorised representatives to insure an effective interface of operations;

3. establishes field offices as necessary to insure the rapid and effective furnishing of Federal disaster assistance;

4. implements policies, procedures and systems to insure the provision of effective Federal disaster assistance;

5. insures the timely furnishing to affected citizens and public officials the Federal disaster assistance to which they are entitled.

Emergency Operations Office

The Emergency Operations Office, headed by the Federal Co-ordinating Officer, is responsible for co-ordinating all forms of assistance. For each resource or service required, a special group within the office has full responsibility. Among the groups established with each large-scale disaster are:

- Food Operations
- Shelter and Temporary Housing

- Health and Medical Services
- Telecommunications
- Transportation
- Utilities
- Debris Clearance
- Search and Rescue

Each group is headed by a co-ordinator with full authority to act for the Federal Co-ordinating Officer in all matters relating to his group's area of responsibility. Staffing each group are predesignated representatives of Federal and State agencies having responsibilities for the fulfillment of the group's operations. Because OEP lacks sufficient permanent staff to provide co-ordinators for each resource or service area, arrangements have been made with appropriate Federal agencies within each region to provide a man on detail to OEP to act in this capacity. Detailing a man to OEP rather than delegating full responsibility to another Federal agency serves two purposes:

1. it provides for reimbursement from OEP's administration fund for services rendered;
2. it precludes conflicts among agencies that may be adverse to subordinating their activities to those of another Federal agency when disaster legislation specifically vests such authority in OEP.

Within the Emergency Operations Office, each group is responsible for carrying out all aspects pertinent to its area of responsibility. Groups utilize the services of other organizations and the Federal Co-ordinating Officer's staff, as appropriate. The Emergency Operations Office:

1. co-ordinates all requests for disaster assistance to individuals, State and local governments;
2. works with State and local officials in obtaining all types of required disaster assistance;
3. receives, in co-operation with the Red Cross, all requests regarding status of individuals in the disaster area.

Individual Assistance Division

The Individual Assistance Division co-ordinates the field activities of all Federal agencies offering assistance directly to individual disaster victims. The division is headed by an OEP representative, who acts as co-ordinator for individual assistance.

The division is responsible for making advice and assistance readily available to disaster victims by operating "one-stop disaster assistance centers" throughout the disaster area. These are staffed with representatives of all Federal, State and charitable agencies having individual disaster programs. Additional staffing includes assistance advisors who can work with each victim in determining the types of assistance he requires and in making necessary application for assistance. Applications that must be filed for different types of assistance are being standardized as much as possible.

The co-ordinator for individual assistance works with the Administrative Services office in obtaining necessary office space for each center, with the Information Office for publicizing the location of centers and with the Transportation Group for assisting victims who may have difficulty in getting to the centers.

The Individual Assistance Division:

1. co-ordinates and secures Federal assistance to individuals;

2. reaches individuals needing assistance instead of waiting for individuals to contact Federal authorities;

3. co-ordinates to the highest degree possible the assistance activities of the Red Cross and private organizations;

4. works with Federal agencies to speed up regular benefits to disaster victims.

Public Assistance Division

The Public Assistance Division consists of representatives of Federal agencies that administer programs designed to aid in the longer-range recovery of disaster-stricken political subdivisions. The co-ordinator for public assistance advises State and local officials regarding aid available and processes all such applications.

The Public Assistance Division:

1. receives requests and works with political subdivisions to secure the assistance to which they are entitled;

2. co-ordinates all disaster assistance to State and local political subdivisions.

Senior Military Advisor

The Department of Defense has assigned responsibility for all disaster assistance to the Department of the Army. Generally, the Senior Military Advisor is an officer assigned to the headquarters of the US Numbered Army responsible for the area affected by the disaster. Assistance provided by the Armed Forces is primarily of an emergency nature. Due to the inherent emergency capabilities the Armed Forces participates as necessary in each of the resource and service areas established within the Emergency Operations Office.

The Senior Military Advisor:

1. advises the Federal Co-ordinating Officer of military resources available for disaster assistance;

2. secures military assistance when requested by the Federal Co-ordinating Officer or his duly appointed deputies;

3. co-ordinates (for the Federal Co-ordinating Officer) all military assistance.

State Co-ordinating Officer

State and local governments have the primary responsibility for disaster assistance in the United States. These officials are the first to initiate disaster assistance operations and continue to be involved until all such activities are completed. The State Co-ordinating Officer is assigned by the Governor of the affected State to manage and direct the State and local assistance effort.

The State Co-ordinating Officer:

1. advises the Federal Co-ordinating Officer of State and local resources employed or available for disaster assistance;

2. manages and directs the overall State and local assistance efforts;

3. co-ordinates with and advises the Federal Co-ordinating Officer throughout the assistance effort.

Intelligence Office

Following a disaster, a large amount of information is needed to assess the severity of the disaster and to determine the type and amount of assistance needed. Damage surveys and estimates of the situation are made by a variety of agencies. The establishment of a single Intelligence Office provides a focal point for gathering and processing all necessary information and for insuring its accuracy and currency. Requirements are levied on all agencies having the expertise and the responsibility for certain classes of information to guarantee that the Intelligence Office obtains all data necessary for determining requirements, measuring performance, and preparing official situation reports.

The Intelligence Office:

1. collates and analyzes all disaster assessment information and prepares appropriate reports regarding the economic and social impact of the disaster;
2. gathers information regarding the need for post-disaster evacuation;
3. estimates needs for resources based on surviving resources and disaster requirements;
4. develops official situation reports from all submitted or developed information.

Information Office

Following a disaster, disaster victims must be kept informed of the locations and kinds of assistance activities, and of various measures that they may take to help themselves. Normal communications channels may be impaired. Even when they are not, victims may not have ready access to them. In addition to the information needs of disaster victims, the news media seeks information on the impact of the disaster, the status of its victims and the progress of relief activities.

To achieve the widest dissemination of accurate and current information, the Information Office collects and verifies information from all appropriate sources and uses all means of communication to disseminate facts.

The Information Office:

1. provides information to individuals on assistance available and where assistance may be obtained;

2. prepares, in co-ordination with the State, appropriate press releases and is the official spokesman for the Federal Co-ordinating Officer regarding Federal disaster assistance activities;

3. co-ordinates and responds to all public information requests.

Civil Rights Office

Experience has shown the wisdom of aggressively pursuing civil rights compliance. To preclude the incidence of discrimination and to insure that disaster victims have easily accessible recourse in any cases related to civil rights compliance, a Civil Rights Compliance Office is established as part of the field organization.

This Civil Rights Compliance Office:

1. insures compliance with all civil rights laws and procedures in the administration of Federal assistance programs;

2. investigates all complaints regarding discrimination in the provision of Federal disaster assistance;

3. works with the Information Office to insure that disaster victims fully understand their rights and that charges of discrimination do not result from misinterpretation of Federal assistance programs.

Administrative Services Office

In every disaster in which on-site Federal operations take place, participating agencies require adequate office space and equipment, clerical personnel, transportation, communications and personnel support services for their staffs (food and shelter). In the past, each agency and each individual was responsible for attending to these matters independently. This often resulted in delays before agency activities got fully underway, in inefficiencies or in special problems.

To insure that agencies begin operations as soon as possible and in a co-ordinated fashion, the field organization includes an administrative support office with responsibility for supporting all operating agencies.

The Administrative Services Office:

1. arranges for the establishment of a command and control center, securing office space, equipment, supplies, and temporary help;

2. assures the securing of the necessary telecommunications equipment in co-ordination with appropriate personnel;
3. arranges for living accommodations and other support services for Federal disaster assistance personnel;
4. co-ordinates and arranges VIP tours and briefings;
5. undertakes other necessary administrative support functions for the Federal Co-ordinating Officer.

III. Summary

Preparedness and organization for efficient use of available resources results in effective and comprehensive disaster assistance operations. The Office of Emergency Preparedness, through the Federal Co-ordinating Officer, assigns specific responsibility for disaster relief work to various Federal agencies on the basis of their respective specialized abilities. The Federal Co-ordinating Officer works directly with the State Co-ordinating Officer to insure satisfaction of requirements at the local level. The OEP Field Organization described in this paper is the mechanism utilized in the United States to insure a prompt disaster response.

CCMS No.2

INDIVIDUAL ASSISTANCE PROGRAMME LUBBOCK TORNADO DISASTER

Office of Emergency Preparedness (United States)

I. BACKGROUND

A. The City of Lubbock

Lubbock, Texas is located in the south central portion of the Texas Panhandle approximately 300 miles west and slightly north of the Ft. Worth - Dallas area and 115 miles due south of Amarillo. Lubbock serves as the major trade center for a large portion of West Texas and eastern New Mexico. Major highways, railroads and airlines intersect in Lubbock and provide varied means of transportation to support the heavy concentration of industries related to the cotton and grain trade. With a population of approximately 170,000 people, Lubbock is a thriving American urban area that encompasses a variety of racial and social groups, primarily orientated to the fields of education and agriculture.

B. The Tornado

On the evening of 11th May, 1970, at approximately 10.00 pm CDT, a devastating tornado tore through a major portion of the City of Lubbock. Two tornadoes touched down east of the Texas Technological University and made discontinuous contact with the ground until they united at approximately the intersection of US Route 48 (Avenue Q). From this point the single tornado traveled on the ground in a northeasterly direction for approximately seven miles to a point just east of the Lubbock Municipal Airport. The funnel-shaped path through Lubbock was approximately 1/2 mile wide at its narrow end and 1½ miles wide at its widest point. An estimated 2,500 square blocks were affected by the twister.

C. The Aftermath

A total of 26 people were killed as a result of this tornado. Approximately 1500 individuals were injured and received medical treatment with 96 requiring hospitalization. The cost of property damage is estimated to be $125,000,000 or approximately 10% of the Lubbock city tax base destroyed. Outside of the tax base, property damage was approximately $75,000 including damage to utilities, 119 small aircraft and 10,000 private automobiles. Damage surveys indicate the following:

Dwellings destroyed	460
With major damage(*)	489
With minor damage	764
Trailers destroyed	80
Trailers with minor damage	30
Apartment units destroyed	600
Small businesses destroyed	250
Total families suffering loss	2,338

Rescue effort, emergency assistance, and long-range rehabilitation programs were implemented within minutes after the initial shock of this, the city's worst storm.

II. FEDERAL GOVERNMENT RESPONSE

A. Office of Emergency Preparedness

On the morning of 12th May, 1970, OEP Region 5 Director Hastings arrived in the disaster area and met immediately with City officials. At the request of the President, George A. Lincoln, Director of OEP, accompanied by Texas Congressional members and OEP staff, flew to the disaster area to make aerial and ground surveys of the stricken City. The survey party arrived on the afternoon of 12th May, 1970 and was met by Regional Director Hastings. The preliminary survey indicated that damages were severe enough to qualify the City of Lubbock as a major disaster area.

On 13th May, 1970, President Nixon, at the request of the Acting Governor of Texas, declared a major disaster for Texas and authorised the use of Federal funds to supplement State and local resources for relief measures in nine northwest Texas counties affected by a series of tornadoes on 17th and 18th April and on 11th May, 1970. Federal funds authorised by this declaration are to be used for temporary housing, unemployment compensation for disaster victims, and recovery work including debris removal from public and private property, restoration of publicly-owned utilities and the repair or replacement of streets, bridges and other public facilities affected by the tornadoes. The Office of Emergency Preparedness Regional staff in Denton, Texas, under Regional Director George Hastings, administered the funds allocated for this disaster and directed Federal disaster relief measures in the stricken area.

OEP, working with the State, established a temporary Field Office in the City of Lubbock. This field office became the focal point for co-ordination of Federal and State agency activities. Immediate action was initiated to survey damages to public buildings, streets and roads, and publicly-owned

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(*) Beyond the ability of the average resident to make repairs.

utilities. Separate estimates of debris to be removed from public and privately owned property were prepared by the Corps of Engineers. Damage to public schools in the disaster area was surveyed by representatives of the Office of Education. By 15th May, the Defense Electric Power Administration reported that power was available to all essential public facilities that were serviceable. Restoration of power by both the SW Electric Co. and the City of Lubbock was initiated within the first few days and continued until power was available to all surviving buildings and homes. Buildings and homes in the most severely damaged area will not require power until they are completely rebuilt. Emergency power in the initial crisis period was provided by the US Fourth Army.

The first contract for removal of debris from public property was awarded by the Corps on 16th May, 1970. Action on removal of debris from private property depended upon the speed the City reviewed and approved applications. (This procedure was slowed down considerably by the lack of decisive action on the part of the insurance companies). Completion of debris removal work is expected by the end of August. Food, health, water and sanitation needs of the City were quickly met by State and Federal agencies with expertise in these resource areas.

Periodic meetings of all local, State and Federal agencies involved in public assistance were conducted by Regional Director Hastings. Close and continual liaison was maintained with the Mayor and City Council of Lubbock, particularly with regard to their responsibilities under the various legal authorities available to disaster assistance.

B. Department of Agriculture

Once the mass feeding operations began to be phased out and as displaced families were moved into temporary housing, the Department of Agriculture (USDA), through the County-City Welfare Department, established a Commodity Distribution Program at a warehouse near the temporary housing. Families in need could obtain a two-week supply of commodities as well as food vouchers at the warehouse. Transportation was provided for the people still living in the Guadalupe area to and from the warehouse (several miles from their homes). Working in tandem with the Commodity Distribution Program was USDA's Expanded Nutrition Program. As each family received commodities they were instructed to speak to a representative of the Expanded Nutrition Program who told them how to use the commodities and provided them with recipes (pictorial recipes were available for those who could not read). In addition, nutrition workers went into the victims' homes to help families learn how to operate new equipment and instruct them in sanitation matters. This program was particularly helpful to the Mexican-American families to whose normal diet the commodities were often foreign and for whom the proper operation of stoves, ovens, and refrigerators, etc. was a real mystery.

C. Department of Housing and Urban Development

Unusual circumstances existing in Lubbock at the time of the disaster enabled DHUD to provide temporary housing to disaster victims almost immediately. The area had available a large number of FHA/VA repossessed homes:

FHA Houses	582
FHA Apartments	78
VA Houses	83
Public Housing	15
Total	758

These housing units, for the most part, had been vacant for several years and had been vandalized; consequently many were in a state of disrepair. Despite the lack of furniture, stoves, refrigerators, power and in some cases, functioning toilet facilities, the City decided to place displaced families in these homes rather than keep people in a mass shelter area. Six plumbing concerns (35 plumbers) went to work immediately to correct these conditions. Nevertheless, no arrangements were made with the Red Cross or any other agency to provide such things as cots and portable toilets for use until the houses could be readied for occupancy. Although the City's decision may have been premature, the quality of the housing supplied was superior to that lost in the tornado. By Monday, 1st June, 655 housing units were occupied by disaster victims and 40 additional applications for housing were being considered.

D. Office of Economic Opportunity

OEO provided funds to the State Welfare Department enabling it to distribute food and medicine vouchers. These funds came from OEO's Emergency Food and Health Program. OEO also supplied personnel to assist the State Welfare Department in the distribution of these vouchers. Some confusion resulted from this program, however, because Red Cross and Salvation Army were also engaged in distributing food vouchers. Once the duplication of effort was revealed, Red Cross discontinued its food voucher efforts.

While legal aid was being provided by volunteer lawyers from the City, OEO supplemented this effort by providing a number of bilingual lawyers during the third week following the disaster.

OEO personnel organized and conducted an "outreach" program beginning on the weekend of Ist June. Efforts were concentrated in those areas not reached by the one-stop centers.

E. Small Business Administration

The Small Business Administration moved quickly after the disaster. By Thursday, 14th May, four SBA offices were operating. Bilingual Mexican-American loan processors were brought to Lubbock from all parts of the country to supplement the local field force. In addition to office staff, SBA dispatched three Spanish-speaking teams to outreach efforts to ensure that victims were aware of the loans available through SBA. Through 20th June, the SBA had approved the following loans in connection with the Lubbock area disaster:

761 Home Loans	$3,237,070
133 Business Loans	2,725,200

The $1800 forgiveness clause applied to the majority of these loans. Close co-operation between SBA and the Red Cross developed as assistance efforts progressed. Red Cross reviewed all loan applications rejected by SBA to see what could be done under their programs. In the Cherry Point one-stop center, all disaster victims could speak to both agencies thus assuring comprehensive and consistent assistance.

F. Corps of Engineers

Under the direction of OEP, Corps personnel and equipment moved into Lubbock immediately after notification of the disaster. A detailed survey of the downtown area was completed by I5th May: approximately 240 city blocks contained some form of debris in streets, alleys and on private property. A complete damage survey of the entire disaster area was completed by 18th May. The first contracts for removal of debris from public property were awarded on 16th May; by 23rd June, 57,000 cubic yards of debris had been removed from public property and 97,000 cubic yards from private property. These figures represent 454 requests of an expected 1500 requests, 1264 of which are now on hand.

G. Red Cross

The American Red Cross provided eleven mobile feeding units and served approximately 100,000 meals during the crisis period. Two large shelter areas were quickly established and, at peak, sheltered approximately 3,000 people. Because of the availability of temporary housing, the shelters were quickly emptied and practically closed out by the end of the second week. Nearly 1300 families applied for recovery assistance and it is estimated that the Red Cross will spend nearly $750,000 to assist them. A staff of 50 manned this disaster assistance operation for the Red Cross.

H. Department of the Interior

Representatives of the Defense Electric Power Administration surveyed the damage to power plants and to the water system. These representatives stayed on the scene until the utilities were adequately restored.

I. Department of Labor

The Department of Labor authorized the expenditure of $350,000 for Operation Mainstream activities in the disaster area. A total of 219 people were hired to clean up debris under the Neighborhood Youth Corps program.

J. Department of Commerce

Business and Defense Services Administration personnel surveyed the disaster area to determine the extent of damage to plants holding defense contracts. No action was required. The Economic Development Administration is considering funding the newly established Lubbock Citizens Rehabilitation Advisory Commission, to assist the long-range economic rehabilitation.

K. Department of Defense

US Fourth Army personnel responded to notification of the disaster by sending a liaison team to Lubbock to co-ordinate with the OEP Regional Director. Two helicopters and crews were used to get to the nine outlying counties to advise people and governments on the assistance available.

L. Office of Civil Defense

STRATCOM personnel from the OCD Region Five office brought emergency radio equipment to Lubbock and established radio communications with the OCD Region Five office in Denton, Texas. Regional staff co-ordinated closely with State OCD personnel throughout the recovery period.

M. General Services Administration

The local GSA representative provided assistance to OEP and other Federal agencies in obtaining space and facilities (details reported under Individual Assistance section). The local GSA telephone switchboard personnel worked long and hard assisting officials involved in the disaster assistance effort.

N. Department of Health, Education and Welfare

Food and Drug Administration personnel worked closely with City officials to inspect food, drugs, and veterinary medicines. A total of 300 tons of food ultimately were declared contaminated. National Communicable Disease Center representatives reported that encephalitis was endemic in the Lubbock region and that ground spraying for mosquito larvae was recommended. Spraying equipment was flown in from New York on 22nd May, because the County-City spraying equipment was destroyed in the tornado. Office of Education teams inspected area schools for damage and provided transportation and lunches to 500 students displaced by the storm. The Social Security Administration established offices in Lubbock to advise victims, handle payments and facilitate change-of-address procedures.

O. Internal Revenue Service

IRS representatives held community meetings to inform people of tax relief.

III. STATE AND LOCAL ACTIVITIES

The Lt. Governor and State agency heads arrived in Lubbock on 12th May. Representatives of State agencies established offices in the City's Emergency Operations Center. A representative of the State Office of Civil Defense was named the Governor's representative and he co-ordinated closely with OEP Regional Director Hastings. Throughout the crisis period State and Federal personnel worked closely together contributing greatly to the speed of the initial recovery. As needed, State representatives stayed on in Lubbock as the restoration and rehabilitation period began.

Local response to this sudden disaster came within minutes. Before telephone lines were restored that could reach the State capital, the City Manager ordered the State National Guard to serve to prevent looting and to control the disaster area. The Mayor quickly established an evacuation system for the injured and authorized the establishment of a temporary morgue. Recovering quickly from the initial shock of the disaster, the local officials worked hard and long to bring speedy aid and recovery to their citizens. Co-operation on all three levels of government were excellent.

Volunteer groups, churches, civic organizations and single individuals sprang to the aid of their fellow citizens and community spirit reached a high point in the history of this mid-American city.

IV. INDIVIDUAL ASSISTANCE PROGRAMS

A. The OEP Field Office

The increased attention and responsibility given to OEP in the individual assistance area has resulted in the development of new concepts of operation geared to make the total Federal response effort more efficient and effective. The Lubbock tornado disaster offered an opportunity for OEP to field test the individual assistance concept under actual disaster conditions. The decision to field test this concept was made even though the OEP Regional Office personnel had not been trained in the areas of individual assistance. Furthermore, the new concept had not been reviewed by other Federal agencies at the National level. In spite of these limitations a special team from OEP National Headquarters flew to Lubbock, Texas on 14th May to establish individual assistance programs.

The OEP Field Office was expanded to provide space for representatives of Federal and State agencies involved in assisting individual disaster victims. While the primary headquarters' locations for most agencies were established elsewhere in the City, each agency did place a representative in the OEP Field Office to maintain constant liaison with OEP. Periodically, Regional Director Hastings held meetings at the Field Office with these agency representatives to review the status of individual assistance programs. This Federal and State agency field organization (see Appendix C) served as an efficient coordinating body and provided OEP with the means for coordinating the total disaster relief program.

B. Outreach

Under the direction of OEP personnel, outreach programs were conducted by the Small Business Administration, local charitable groups and the Red Cross. These programs were directed primarily at individuals needing assistance from these agencies. In order to assure that disaster victims were receiving or were aware of all forms of assistance available, OEP requested that OEO organise and conduct a separate outreach program concentrating on areas not covered by other agencies.

C. Public Information

OEP personnel prepared and coordinated the public information effort. News releases and radio and TV stories were prepared for the general public and for those affected by the disaster. Full page newspaper advertisements, in both English and Spanish, were run continuously informing the victims of the assistance available, the location of the one-stop centers, and the location and telephone numbers of all other Federal and State assistance agencies. Handouts containing similar information, again in both languages, were distributed through churches and by agencies.

D. "One-Stop" Centers

Following a complete tour of the disaster area, conferences with local and State officials and a briefing on the nature of the disaster victims, it was concluded that the establishment of "one-stop" centers as satellites of the Individual Assistance Office was feasible and desirable. Even though some agencies were well-established in the Lubbock area, two centers were considered necessary to meet the needs of these tornado victims. Two factors bearing on this decision were the excellent quality of the City Government and the geographic concentration of the actual disaster area. Alternative means of reaching the people may have been employed had other conditions existed.

One center was established in the Guadalupe section of the City and the second at the Cherry Point residential area. The Guadalupe area was in the centre of the tornado path and had been the home of the City's Mexican-American people as well as a commercial and industrial center. The Cherry Point sub-division was a suburban residential area where approximately 600 vacant homes were held by FHA and VA as repossessions. The majority of the Mexican-American disaster victims were being placed in these homes on a temporary housing basis.

The two centers, designed to provide information and services to disaster victims, were located in previously existing community centers in the respective areas. In the Guadalupe area, the Guadalupe Community Center and Catholic Charities were already established in the community center building. The distribution of clothing, furniture and food was being carried out at this local point of community life. In the Cherry Point area, the Northeast Community Center and MiCasita Home Counseling organizations were already established and working with displaced victims assigned to the FHA homes. Furthermore, establishment of the "one-stop" centers at these two locations appeared advisable because of the need for bilingual volunteer assistance to aid the disaster assistance agencies. During the weekend, 16th-17th May, arrangements for space in the two community centers were finalized and telephones, tables, chairs, etc. were obtained. Public information posters, handouts, and media releases covering the services available at these centers were prepared in both Spanish and English. Flyers were distributed through the local churches on Sunday, 17th May, a most successful operation. Responsible personnel and volunteers were also briefed on the proposed operation of the two centers. On Monday, 18th May, the two one-stop centers opened to the public for the first time.

The basic concept of the one-stop center is simple. It recognizes that traditionally, each disaster victim was left on his own to discover any available assistance as well as its source. The normal confusion and bewilderment of victims immediately after a disaster has struck makes their task of finding and qualifying for various forms of local, State and Federal assistance monumental. To ensure that people get the assistance they deserve according to the law as quickly and painlessly as possible, the one-stop center was established to bring together all the local, State, and Federal agencies able to provide some form of disaster assistance and relief. While the center is primarily an information dissemination point, some services can be provided directly from the center. The primary objective of the center was to ease the burden on the disaster victim by giving him immediate access to the entire assistance package, but a secondary objective was to coordinate the efforts of the local, State and Federal agencies.

The Lubbock disaster provided an opportunity to learn much about the practicalities of this concept during actual operations. The two centers were sufficiently different in configuration and operation to provide a legitimate comparison of two approaches toward the same objective.

Housed in the Guadalupe Community Center were the Federal Housing Administration, the Salvation Army, the Texas Employment Commission, the Lubbock Bar Association (providing free legal aid to disaster victims), the City Attorney's Office (taking applications for debris clearance on private property), the State Welfare Office (distributing OEO food vouchers), and the Texas A & M Extension Service's Expanded Nutrition Program (a part of the Department of Agriculture Extension Services). The Red Cross was housed diagonally across the street in St. Joseph's Convent; the Small Business Administration was located in St. Joseph's Parish, adjacent to the convent. Both Red Cross and SBA had established their offices prior to the announcement that OEP would be opening one-stop centers. Since these offices were well-established and were in close proximity to the Community Center where facilities were limited, the agencies were not asked to relocate their operations. SBA did station one man in the Community Center to assist the Legal Aid staff and to be sure that Victims were made aware of SBA's location.

Housed in the Northeast Community Center, Cherry Point area, were the FHA, the Red Cross, the Texas Employment Commission, the Salvation Army, the City Attorney's office, SBA, the Lubbock Bar Association and OEO personnel (distributing OEO food vouchers for the State Welfare Office). All assistance groups were located under one roof with the majority of agencies set up in one common room. Previously established in the same area (about three blocks from the Northeast Community Center) was a County-City Welfare Office that was administering the Department of Agriculture's Commodity Distribution Program. Because of the large quantities of food that had to be stored and controlled, contiguous facilities could not be made available.

The operation of the two one-stop centers gradually changed over time as the rehabilitation stage of recovery came into full swing. Initially, agencies providing emergency needs - food, clothing, shelter, etc. were busiest. By the end of the second week, the emphasis had shifted to these agencies concerned with recovery assistance needs - grants, loans, debris clearance, employment, etc. Correspondingly, as residents of the Guadalupe area were re-located in temporary housing in the Cherry Point area, the work load shifted to the Northeast Community Center location. By Friday, 29th May, the work load at the centers had settled down to the point that the Red Cross, the Salvation Army, FHA, and Agriculture Services could withdraw from them to their other office locations in Lubbock. Only the Texas Employment Commission, the City Attorney's Office and Legal Aid remained at Guadalupe as of 2nd June. SBA moved on 1st June from the parish to the Guadalupe Elementary School, still across the street from the center. SBA, the Texas Employment Commission, the City Attorney's office and Legal Aid continued to work in the Northeast Community Center. Throughout this period the two one-stop centers were under the supervision and control of an OEP representative. From 18th May to 2nd June, the coordination was provided by a mmmber of the National Office staff. After 2nd June, the minimum supervision required was provided by OEP Region Five personnel.

V. CRITIQUE OF THE INDIVIDUAL ASSISTANCE PROGRAM

On Monday, 22nd June, 1970, in Lubbock, Texas, representatives of Federal, State and local departments and agencies reconvened to review the Individual Assistance Program conducted for the benefit of Lubbock tornado victims. Particular emphasis was placed on critiquing the prototype one-stop center program used for the first time during this disaster.

Following are the principal strong and weak points of this program and recommendations for future consideration:

A. Strong Points

1. There was nearly universal agreement that the one-stop concept is excellent and should be further refined, formalized and adopted as a permanent part of the Federal Government's disaster assistance program.

2. The disaster victims benefited by being able to obtain a variety of types of assistance as a result of one visit to one location.

3. Locating all of the agencies together provided an opportunity to identify duplication of effort and to initiate corrective action.

4. Locating all of the agencies together provided an opportunity for each agency to learn more about the other's assistance program and, in some cases, brought about closer working relationships.

5. The close involvement of State and local agencies with Federal agencies gave the representatives of these agencies an opportunity to better understand the scope and nature of Federal programs.

6. The concentration of disaster assistance services in a few specific locations aided the public information personnel in preparing information handouts and media releases.

7. The center provided the public information officer with a known location for contacting agency representatives and consequently saved time in the performance of the information-gathering function.

8. All representatives agreed that the centers provided an excellent information dissemination point. Some representatives felt that services as well as information could be most efficiently disseminated through the one-stop center.

9. The centers quickly became focal points for satellite operations that, while not critical to disaster relief, become increasingly important as people strive to restore normality to their lives. Operations as such include child care programs, change-of-address and the re-establishment of community and social groups.

10. The use of bilingual personnel in the centers and on the outreach teams contributed considerably to the success of the program.

11. The outreach effort was partially responsible for the elimination of overlaps and gaps in assistance efforts.

B. Weak Points

1. Supervision of the centers was provided by one OEP man who spot-checked each center twice a day. The participating agencies saw this as a weakness in the concept and strongly recommend that future centers have a full-time OEP-assigned manager at each center.

2. The use of existing community centers caused some confusion among victims and tended to give the impression that disaster assistance was available only to those people identified with that particular community center.

3. One-stop centers were not established soon enough in Lubbock. If OEP intends to establish a center or centers, it should be done early enough to provide time for all agencies to plan around that program.

4. The space selected for one of the centers was inadequate. Selection of a one-stop center site should consider the need for privacy that lightens the victim's burden when applying for grants or loans. The facilities selected should be large enough to house all assistance agencies, except for those dealing in medical services beyond first aid, commodities and other specialized assistance.

5. Handling of victims entering the Guadalupe center was inadequate. Centers should be arranged so that all victims must pass a reception point where registration and information can be compiled.

6. Variations in agency reporting format caused difficulty in developing an overall assessment of the disaster. Uniform registration and reporting systems, meeting the requirements of all participating agencies, should be developed and incorporated in the one-stop center concept.

7. Coordination of the outreach effort began too late. Some agencies had virtually completed their outreach effort before OEP personnel initiated control over this portion of the Individual Assistance Program.

C. Recommendations

1. If the disaster is relatively concentrated, establish the necessary number of centers within the first 48-72 hours after the disaster; if the disaster is not concentrated consider alternative means of reaching the disaster victims.

2. Require Federal agencies to utilize the centers to the fullest extent and provide at least a liaison representative for each one.

3. Select a public building to house the center if at all possible. Schools seem to offer the best possible physical arrangements. Avoid the selection of buildings that are identified with a local community organization if possible. Look to GSA for expertise in locating and furnishing the centers.

4. Broaden the one-stop center to provide for mobile assistance units when a disaster covers a larger area and victims are widely dispersed.

5. Introduce experience of other disasters and finalize the one-stop center concept and introduce the program formally at the National and Regional levels.

6. Train OEP Regional personnel to establish and manage these centers in future disasters.

7. While the one-stop concept had a high degree of success in the Lubbock disaster, its application in future disasters must be considered carefully in light of the existing circumstances.

8. Meet with the agencies involved in outreach programs as soon as possible after the disaster. Subdivide the disaster area and assign complete outreach responsibility to an agency or group in each subdivision.

D. Summary

The lessons learned in the Lubbock disaster have been analyzed and briefed in the form of guidelines to be used by Federal assistance personnel in future disasters. These guidelines are intended as background material for consideration and coupled with individual experience may serve as a source for developing specific checklists of action needed to establish the Individual Assistance Program.

APPENDIX
CCMS No.2

GUIDELINES TO INDIVIDUAL ASSISTANCE PROGRAMS

The function of the Office of Emergency Preparedness at the scene of all major disasters is to direct and coordinate the public and individual assistance programs of the Federal Government and to facilitate the integration of Federal, State, local and private organizations in the overall assistance effort.

These guidelines are intended to assist OEP officers in setting up the OEP Field Office and in effectively administering the Individual Assistance Programs.

I. Preliminary Assessment of Situation; Present and Potential Response Capability Required

A. Survey present disaster situation:

- nature of disaster
- geographical areas affected
- estimated casualties: dead, injured
- estimated property damage: public, private
- estimated number of homes damaged or destroyed
- estimated number of people homeless
- estimated number of people needing food and shelter
- estimated number of people unemployed as a result of the disaster.
- estimated number of businesses destroyed or damaged
- description of any unusual situation or problem area which will necessitate a special type of response

B. Coordinate with State and local officials to ensure full Federal-State cooperation.

C. Determine which Federal agencies are represented on the scene:

- establish contact with each
- determine location of various agency offices
- determine number of personnel on hand

- determine needs for additional personnel
- determine present and potential extent of the activities of all agencies

D. Determine what other Federal, State, local and volunteer agencies are needed at the disaster scene to administer individual assistance programs.

II. Establishment of OEP Field Office

A. Determine which agencies involved in the individual assistance effort should be represented in the OEP Field Office. The following agencies will probably be represented at every major disaster:

Small Business Administration

Red Cross

Salvation Army

Housing and Urban Development

Health, Education and Welfare

Agriculture

Office of Economic Opportunity

State agencies

Local agencies

Additionally, these agencies may be necessary:

Labor

Veterans Administration

State Insurance Commission

Other Volunteer/Charitable organizations (national and local)

B. Coordinate with GSA in selecting best site for the OEP Field Office. Accessible location and floor space sufficient to house representatives of each agency involved in both the public and individual assistance programs must be prime factors in selection. As far as possible rely on GSA to determine office equipment and supplies necessary for the office operations. (Review application forms, records, etc. to ensure sufficient supply and currency). GSA should be prime source for procurement of all necessary supplies and furnishings.

C. Consider the Individual Assistance Division of the OEP Field Office which will:

- coordinate the activities of all agencies involved in individual assistance programs;
- integrate the activities of all agencies with private relief organizations;
- report on these activities to the Federal Coordinating Officer;
- coordinate outreach efforts of agencies such as SBA, OEO, Red Cross and local and private groups;
- coordinate public information activities as related to individual assistance;
- coordinate transportation requirements of agencies involved in individual assistance activities to ensure that all victims are contacted;
- develop an organizational chart of Field Office and satellite or mobile units for use by State and local agencies and officials - complete with names etc.;

(Note: The reporting of the individual assistance activities is essential. Preferably it should be assigned to one OEP officer who should have authority to enforce reporting requirements on all other involved agencies).

III. Establishment of Emergency Assistance Centers

A. Determine if emergency assistance centers should be established. For example: are victims concentrated in one area, can most of them reach a central point easily, are there some suitable facilities for a one-stop center; is more than one center needed? If these kinds of questions are answered affirmatively, a one-stop center should be established.

But, if the victims are widely dispersed, a mobile center should be considered. A bus or truck or some similar means of "mass transportation" can be used to transport representatives of agencies involved in the individual assistance effort to the victims. Ensure widespread advertising of time, location of this mobile center. As an alternate, several mobile units could be put together, sent to pockets of victims located in different areas, remain several days to administer individual assistance programs, then either return to "headquarters" or move to another pocket of victims.

B. If a one-stop center is to be established: again coordinate with GSA in setting up the center, in obtaining furnishings and supplies, and meeting communication and transportation requirements.

- Quick action is essential in order to establish centers before other agencies begin to set up independent operations - within the first 24-48 hours is best.

- Site location is critical; centers must be accessible to victims and must be large enough to accommodate the many agency representatives working on individual assistance programs (suggested GSA minimum is 4000 square feet). A public building - schoolhouse - is preferred to a private building simply because it helps remind victims that this assistance is from the Federal Government and it helps keep Federal workers apart from local politics, problems and the like.

- Identify and contact community leaders and enlist their support for the centers. Use their knowledge of local conditions, capabilities for response and recovery.

- Make full use of existing community groups, neighborhood organizations, church and social groups.

- Appoint one manager for the centers - preferably an OEP official - and give him full responsibility for equipping and staffing and running the centers.

- Determine which agencies should be represented in the centers. The following will most probably be needed:

  SBA

  Red Cross

  FHA/HUD

  Salvation Army

  Agriculture

  HEW

  OEO

  State agencies (insurance commissions, unemployment commissions, etc.)

Local agencies

Local voluntary efforts

Legal aid personnel (whether OEO-provided or enlisted from the local bar association to help victims know what they legally may request from the government)

- Consider appointing one local organization to coordinate the local volunteer efforts (a church, neighborhood civic group, Jaycees, etc.); this person or group should be represented in the centers.

- If possible, locate SBA, Red Cross and legal aid people close together - there is much overlap between SBA and Red Cross programs; legal advice is often necessary.

- Communications between centers and the OEP Field Office are necessary immediately. If telephone lines are out, ask telephone company or military to help repair; also use walkie-talkies, messenger services, bell-boys and other means of communications.

- Appoint a receptionist to each center to act as the central control. A definite flow should be established for handling each applicant. The receptionist can help victims fill out registration forms (one uniform form which all agencies can use is being developed) and can direct victims to appropriate agencies for assistance. The receptionist should familiarize herself with all agency programs (the OEP master catalog on disaster-related assistance, also being prepared, will be invaluable; each receptionist and each agency representative should have a copy of this).

- Prepare for large masses of applicants: have parking space, police control, waiting room space, feeding and medical facilities (Red Cross can handle feeding and first aid).

- Consider in advance how long the centers should operate. People will use them as long as they are there, but if centers remain operational long after the emergency period, the real purpose of the effort is lost and self-help rehabilitation efforts could be delayed.

- Identify agencies pictorially. Use of initials (SBA, HUD, etc.) is confusing to people and this delays their receiving necessary help. This material should be prepared and maintained as permanent supplies.

- If the area is bilingual, be sure that those staffing the centers can speak both languages - in proper dialect. (Volunteers could provide bilingual help here).

- Determine if victims can reach the centers fairly easily; it may be necessary to re-route bus routes or initiate new transportation to help people get to centers (particularly if they have been left homeless and are living in temporary quarters in a different area of the city).

C. Public Information on Individual Assistance

- Emergency Assistance centers (or mobile assistance centers, or any other forms of assistance) must be widely publicized.

- All media should be used as fully as possible - including radio, television, newspapers (stories, ads, etc.).

- Eliminate any possibility of "double sources" of conflicting information.

- Additionally, employ other means of reaching people, such as: sound trucks; posters; leaflets and pamphlets (distributed at churches, schools if functioning, door-to-door); leaflet drops from airplanes if victims are widely dispersed.

- Use pictures as often as possible, or symbols, or other "tell-by-picture" techniques; victims may be illiterate.

- If disaster hits bilingual area, be sure both local languages are used.

- Provide for adequate directional and identification signs for each center.

- The public information effort must be coordinated from the OEP Field Office - probably by the OEP public information officer on the scene.

- This public information effort must be coordinated with local individual assistance efforts. Enlist support from local leaders.

D. Outreach

- Outreach is part public information, part actual assistance. It means, literally, reaching out to the victims, bringing help and information to them rather than waiting for them to find out about assistance by themselves. It is critical to a successful individual assistance program. Firm OEP monitoring and supervision of all outreach activity is essential to a successful coordinated outreach program.

- All outreach workers must be "coordinated" so that all victims are contacted at least once, so that none are neglected while others reached a dozen times. Outreach workers should be generally familiar with all agency programs; they should be armed with pamphlets, leaflets, and other information which can be left with victims if necessary, or used by outreach workers to answer questions.

- Outreach workers must have adequate transportation - so that they can reach victims, however isolated; so that they can help transport victims to central areas for assistance. GSA can provide extra vehicles for this effort if necessary.

- If bilingual outreach workers are necessary, supply them. (Local volunteers might accompany agency representatives and help with the language problem, if any).

THE NATIONAL FLOOD INSURANCE PROGRAM
by George K. Bernstein

In recent years, Americans have increasingly focused their attention on the problems confronting persons subject to severe loss, whether from natural disasters such as flood, hurricane and earthquake, or man-made perils such as crime and riot. Despite continued efforts to both eliminate and ameliorate the impact of these disasters on their victims, it is unlikely that either natural or man-made disasters will disappear as a factor in American national life. Therefore it has become necessary to discover a way to minimize their devastating effects and to aid their victims.

In the past, this concern has been expressed by the United States Congress in one of two forms: disaster relief and rehabilitation measures for disaster victims, or the utilization of various mechanisms seeking to employ the insurance principle. In recent years, however, it has become generally recognized that after-the-fact compensatory measures are frequently inadequate, often inequitable, and almost always degrading to the recipients. As a result, Congress has been giving more emphasis to the use of the insurance mechanism as is evidenced by both the National Flood Insurance Act and the Urban Property Protection and Reinsurance Act. These measures were enacted by the US Congress in 1968. The need for governmental involvement in programs such as these was intensified by the growing reluctance of private insurance companies to make essential property insurance coverages widely available to the public.

Prior to the enactment in 1968 of the National Flood Insurance Act, flood insurance had never been generally available in the United States. The private insurance industry has found it uneconomical to write such coverage. Only property owners living in flood areas were interested in the coverage, with the result that adverse selection was guaranteed, thus making any spread of risk impossible. In these circumstances, the catastrophic potential of flood losses could bankrupt an insurance company. Furthermore, property insurance rates are based on loss and expense experience recorded over a period of years; credible experience data was lacking for flood insurance, but even on the basis of available data those property owners located in a severe flood hazard zone frequently would be unwilling or unable to pay the high premium necessary to obtain coverage. Thus the insurance industry concluded that it was unable to provide flood coverage without Federal Government assistance.

The inability of property owners to obtain flood insurance frequently resulted in a failure to rebuild and replace entire areas stricken by major floods. People often failed to take advantage of available government assistance. It was also apparent that any program of land management and other control measures to reduce the destructive effects of floods in inhabited areas would require assistance and direction from the Federal Government. Since the Federal Government was already providing disaster relief as well as low interest loans to assist in the reconstruction of damaged property, government aid in providing low-cost insurance appeared to be a logical extension.

As a result of Congressional concern, a Federally sponsored flood insurance program was initially enacted in 1956. A major problem at that time was the difficulty in developing a schedule of rates which would be adequate to pay all the claims incurred within a reasonable period of time. As presented to Congress in 1956, the proposed flood program set forth a rate structure which did not reflect the risk variation in different locations on the flood plain. This tended to support the insurance experts' belief that sound actuarial rates could not be established. The Appropriations Committee of the House of Representatives considered this rate structure inadequate as the basis of a viable flood insurance program and concluded that a more extensive study was a prerequisite for establishing a program of this nature. As a result, the original flood insurance proposal failed to receive the necessary appropriations from Congress and thus never became operative. However, both the need for such a program and an active interest in establishing one remained.

In view of the demonstrated critical shortage of flood insurance, following Hurricane Betsy in 1965, Congress, in the Southeast Hurricane Disaster Relief Act of 1965, directed the Secretary of the Department of Housing and Urban Development to undertake a study of the feasibility of providing flood insurance at the Federal level. The US Department of Housing and Urban Development conducted the required study with the assistance of the Army Corps of Engineers, Geological Survey, Tennessee Valley Authority, Soil Conservation Service and other American government organizations with technical competence and experience in the field of flooding and flood plain management.

Early in this study it became evident that while the accumulation of credible experience data on which to base flood insurance rates could be accomplished, the previous fear that the rates thus developed would be too high to enable most potential flood victims to purchase policies was confirmed. Some type of public subsidy by the United States Government was imperative during the initial development of the program in order to obtain a broad-based sale of flood insurance and to give private insurance companies an opportunity to build up their reserves.

In August of 1966 the resulting report, "Insurance and Other Programs for Financial Assistance to Flood Victims", was transmitted to the President by the Secretary of HUD. Recognizing the fact that floods are the most serious natural disasters facing the citizens of the United States, the report cited two objectives for any relief measure:

(1) it should help provide financial assistance for victims of flood disasters in order to aid them in the rehabilitation of their property; and

(2) it should, at the same time, help prevent unwise use of land in those areas where flood damages would mount steadily and rapidly. Insurance was the mechanism which was capable of maintaining an acceptable balance between these two goals.

The report therefore concluded that a program of flood insurance was not only feasible but would also promote the public interest. Flood insurance, if properly conceived and operated, would have a complementary rather than a competitive relationship with other Federal Government flood programs such as flood forecasting, warning, protection works, relief and land use management programs. The report concluded that a program of flood insurance was an excellent means of helping individuals bear more easily the risks of flood damage to which their locations expose them as well as an excellent means of discouraging unwise occupancy of flood-prone areas.

In order to establish a workable flood insurance program, certain factors had to be given primary consideration:

(1) As few as two percent of all dwellings can expect to have more than fifty percent of the total average annual flood damage, and less than ten percent of all dwellings have any significant flood hazard at all;

(2) The timing and magnitude of specific floods are unpredictable but the probability of occurrence of a flood of given size is determinable;

(3) The location of flood hazards is identifiable, and the average annual damage by risk zones is reasonably predictable;

(4) The short distance between very high-risk areas and low-risk areas will often make the economic use of some zones possible while at the same time avoiding the use of excessively hazardous zones; and

(5) The variation in damage rates among cities necessitates the establishment of separate actuarial premium rates for each flood-prone area.

In response to the obvious need for Federal Government assistance in establishing viable flood insurance coverage, Congress enacted the National Flood Insurance Act of 1968. A 1969 Amendment to the Act expanded the definition of flood to include mudslides. The program, administered by the Federal Insurance Administration within the Department of Housing and Urban Development, is a co-operative effort between the private insurance industry and the United States Government. An advisory committee composed of representatives of the insurance industry, State and local governments, lending institutions, the home building industry, and the general public assists the Federal Insurance Administrator in carrying out the program. Designed to make at least partial flood insurance coverage available against property losses caused by floods, the long-range goal of the program is to reduce or prevent future flood losses through improved flood plain management.

In order to obtain flood insurance coverage, the initiative must be taken by each individual municipality or by the unit which has authority over zoning and building code measures. A community must submit a complete application which meets all the requirements of the regulations governing the flood insurance program.

First of all, appropriate local officials must demonstrate that there is a local need for flood and/or mudslide insurance coverage and supply evidence of their desire to participate in the program. In doing so, the community's application must first cite the jurisdiction's legal authority to regulate land use; summarize measures (i.e. codes, ordinances, regulations) already in effect which are designed to reduce property damage from flooding and/or mudslides; provide copies of maps showing the areas in the municipality prone to flooding and/or mudslides and a brief history of flooding and/or mudslides experience in the community; and, if available, furnish copies of any official reports on the community's flooding or mudslide programs. Secondly, the community must take legislative action formally committing itself to adopt by 31st December, 1971 and to maintain in force for areas having special flood hazards, adequate land use and control measures designed to reduce exposure to these hazards.

The measures ultimately adopted must be consistent with criteria established by the US Government and should:

(1) constrict the development of land exposed to flood damage where appropriate;

(2) guide development of proposed construction away from locations threatened by flood hazards;

(3) assist in reducing damage caused by floods; and

(4) generally improve the long-range land management and use of flood-prone areas. The community must also co-operate with the Administrator in his efforts to bring the benefits of the program to the area.

Once a community has completed its application satisfactorily, it will be declared eligible for the sale of subsidized flood insurance policies.

An essential purpose of the National Flood Insurance Program is to encourage State and local governments to adopt and enforce land use and control measures. The law does not place responsibility for flood plain management throughout the country on the Secretary of the Department of Housing and Urban Development, but the statute requires that the objectives of a flood insurance program be integrally related to a unified national program for flood plain management.

Land use and control measures should encourage only development of identified flood-prone areas which represents acceptable social and economic uses of the land in relation to the hazards involved, and should discourage all other development in the identified areas of special flood hazards. Consideration should be given to first-floor elevations and the need for bulkheads, seawalls, pilings, or other devices and procedures designed to reduce damage from flooding and to improve the long-run land management of flood-prone areas.

Without the requirement to adopt land use and control measures there would be no incentive in the flood program to reduce losses, and the program would then encourage rather than discourage the injudicious use of the Nation's flood plains. It is hoped that States will develop criteria for their communities to employ in establishing local land use and control measures. The States can also play an important role in this program by reviewing these measures, as well as by assisting the Federal Insurance Administration in establishing program priorities.

Under a 1969 Amendment to the Federal Act, these local ordinances need not be in force before 31st December, 1970, but after that date flood insurance will no longer be made available to communities which have not enacted the necessary zoning and enforcement procedures. The statute prohibits any new flood insurance from being sold within such communities after that date, and existing flood insurance policies will not be renewed.

At a minimum, local land use and control measures must be made applicable to those areas identified by the Federal Insurance Administration on local maps, as precisely as available information will permit, on or before the date flood insurance is first made available to an applicant community. The minimum area of control and regulations should be predicated on the risks associated with the 100-year flood probability.

Regional differences in storms of record and topographical characteristics as related to flood hazards must be considered.

Existing structures generally do not have to meet the new building requirements. There is ordinarily no requirement to either improve or modify existing structures for flood damage protection, since zoning and subdivision regulations are not usually retroactive. However, the flood-proofing of existing structures should be an objective of sound plain management in developing the highest and best uses of land and in protecting owners against unnecessary losses.

Zoning ordinances, subdivision regulations, building codes, health regulations, and other controls for the health, safety, and welfare of the people should be designed to develop the wisest or most economic use compatible with the flood risks. The areas most frequently flooded might be reserved for open space types of use such as playgrounds, parks, parking areas, agriculture, and storage areas. Areas less frequently flooded might be used for industrial, commercial, and multi-story residential use with controls on first floor elevations, use, and occupancy to minimize damages from flooding. The fringe areas which are least frequently flooded might permit all uses, including single-family homes, provided the structures are anchored properly and first floors are above a safe elevation.

Flood insurance coverage is marketed through a voluntary pool of private insurance companies organized under the auspices of the National Flood Insurers Association. Any qualified company licensed to write property insurance under the laws of any State may become a member. Currently there are ninety-eight participating insurance companies which have subscribed a total of over $40 million in risk capital.

Companies which do not wish to pledge risk capital may act as fiscal agents for the association; thus, small companies with limited capital resources are not excluded from participating in the program.

NFIA administers and services the selling of insurance. It appoints an insurance-related firm, generally on a Statewide basis, to act as the servicing office for all flood insurance policies, sold in that State. This servicing office disseminates information both to the public and to insurance agents, processes all insurance policies, and handles the adjustment of claims for loss payments.

Any insurance agent may sell NFIA's flood insurance policy, regardless of whether or not he is licensed through a company which is a member of the insurance pool. The agent must submit the property owner's application for insurance to the appropriate servicing company, which then handles the actual processing of the application and the subsequent issuance of a policy. The agent's commission is paid by the pool at an established rate.

With respect to existing construction, premium rates are maintained at an affordable level by Federal subsidy. The subsidy pays for a share of the operating expenses of the companies and for a share of the losses, thereby permitting the actual premium collected from the property owner to be artificially lowered. Subsidized insurance is prohibited under the Act with respect to new construction located in areas identified by the government as having special flood hazards. In these areas the purchaser must pay an actuarial rate based upon engineering and hydrological evaluation of the actual risk involved. To the extent that the new construction includes flood proofing and higher first-floor elevations, the actuarial rates can be substantially reduced.

Property owners are encouraged to buy enough insurance to give them adequate protection where Federal flood insurance is available and all but low-income persons are denied disaster relief to the extent they could have purchased flood insurance coverage within one year of its availability in their community and did not do so. Many private lending institutions are now requiring that Federal flood insurance be purchased to protect their mortgage loans. Although there is no recommended amount, there are minimum premium provisions of $25 per policy and $4 for any increase in coverage during the life of the policy.

At present, the statutory limits applicable to the subsidized program are $17,500 in coverage for single-family dwellings, $30,000 for two-to four-family dwellings, and $30,000 for small businesses. Additional coverage equal to these amounts can be made available at actuarial rates. Congress has placed a limitation of $2.5 billion on the amount of flood insurance coverage outstanding and in force at any time and a limitation of $250 million on funds borrowed from the US Treasury to pay for losses and expenses.

A flood insurance policy covers losses resulting from the inundation of normally dry land areas from:

(1) the overflow of inland or tidal water,

(2) the unusual and rapid accumulation or runoff of surface waters from any surface, and

(3) mudslides which are caused by accumulations of water on or under the ground.

It does not, however, cover water damage which results principally from causes on the insured's property or within his control, or from a condition that does not cause general flooding in the area. Claims are filed with the policyholder's agent or broker. The industry pool pays its share of any losses out of what remains of collected premium after outlay for allowable expenses. When these funds are exhausted it draws on the fund established by the risk-sharing members of the pool up to a point called the stop-loss point. Beyond this point, all of the industry share of the losses is paid by Federal reinsurance. These reinsurance payments are made out of the National Flood Insurance Fund which is composed of funds borrowed from the Treasury plus reinsurance premiums collected from the pool.

The principles inherent in the flood insurance program are sound, but there have been several problems in making it operational. One initial difficulty was the apathy on the part of local governments and individuals - even those with a high probability of being affected by severe flooding. Improved publicity and an awareness of the benefits of the program combined to help increase vastly the number of applicants as well as the number of participant communities.

Another key problem was the difficulty in developing actuarial rates for communities. The rate studies required under the 1968 Act took up to ten months for a single community, and at the time of Hurricane Camille in 1969, only two communities in the United States had been able to qualify under this program. The enactment of an amendment to the program in December 1969 authorized the Federal Insurance Administration to provide flood insurance for a two-year emergency period ending 31st December, 1971, without the necessity of first determining the individual community's actuarial premium rates. This amendment has enabled the Federal Insurance Administration to qualify more than 300 communities for insurance as of 9th October, 1970.

No change was made in the Act's requirements for the adoption of local land use and control measures as a condition of obtaining flood insurance, and no change was made in the requirement that new construction in special flood hazard areas must pay full actuarial premium rates.

The emergency program is intended primarily as an interim program to provide earlier coverage for potential flood victims pending the completion of actuarial studies. The Federal Insurance Administration has no authority under the emergency program to offer additional limits of coverage to existing construction, and new construction within a special flood hazard area cannot be covered by any Federal flood insurance under the emergency program but must await the establishment of actuarial premium rates.

A simplified actuarial rating procedure has now been instituted, and it is expected that its use will hasten the end of the emergency program and permit flood insurance to be provided broadly under the regular program contemplated by the 1968 Act.

There has been some misunderstanding regarding the requirement to enact and to maintain in force appropriate land use and control measures based on the hundred-year flood probability. Many communities think this prerequisite for coverage will restrict development unnecessarily. Either they do not appreciate the hazards of building in a zone with such a high probability of suffering severe damage from flooding or are unwilling to take the necessary action to reduce such losses. The Federal Insurance Administration is still involved in the task of assisting in the education of local planners and builders in the necessity of wise flood plain management.

It is hoped that, at some future date when land management control and land-use programs have been well established and have reduced the flood loss potential, when the use of flood insurance becomes widespread, and when the actuarial rates have been tested, adjusted and proven establishable, private industry may be able to assume the entire program without subsidy. Until that time, the Federal Government will continue to be the major participant in this program, so that no consumer in a flood hazard area will be denied this much needed protection.

DISASTER ASSISTANCE FOR LONG-RANGE ECONOMIC RECOVERY

by Frank Bourgin (United States)

I. A score of years have passed since the Congress of the United States enacted the Federal Disaster Relief Act in 1950, the first major general legislation that put the Federal Fovernment into the disaster assistance business. Public Law 875 was enacted to provide supplementary assistance to governmental entities to aid in the rapid restoration of public facilities and services. The Disaster Relief Act furnished an ample base on which other legislation could add new kinds of assistance, "after the fact," as disasters occurred. A program that had begun as one of limited and occasional assistance upon a State's request was gradually being transformed into an ongoing vigorous leadership in both preparedness and relief. And then came the Hurricane Camille —— which ushered in more changes in the Federal Government's program than had happened in the twenty years. The year 1969 will undoubtedly be a historical landmark that separates what was and what is still to be. As we move into the seventies to meet the challenges of modern society, this is a good time to take stock and to look ahead. In what directions is the Federal program moving to assist in long-range recovery?

The term "long-range recovery" is unavoidably ambiguous, since strictly speaking, one cannot differentiate between short term "recuperation," the period immediately following a disaster and the longer time frame of "recovery". Hence it is used in a comparative sense. As every student of disasters knows, most actions taken during the emergency period will affect to a greater or lesser degree what happens afterward, and sometimes with an indelible effect. So this paper will refer to some disaster assistance programs that will affect recovery only marginally. The professional economist may protest that the case for large scale Federal assistance is not "proved" by the fact that a disaster affected area recovers more rapidly because of it, and that the same resources inputs might have a greater marginal productivity if used elsewhere. And he may be right. But where the human heart is, and where economic decisions are made under conditions of disaster by political bodies, it is uncommon to measure by a delicate calculus, benefits against losses. As the techniques of analysis and the data gathering are improved, one hopes that the decisions made today under the pressures of emergency will ultimately be replaced by decision making based strictly on economic data that satisfy the canons of rigorous economics. For the time being, we must accept something less, and feel that Federal monies are well spent when it enables the people of a devastated area to get on their feet again, and more quickly if possible.

To the uninitiated, the American disaster assistance program will appear as a piecemeal accretion of legal and practical precedents. The law passed in 1950 was hardly more than a summary of what had taken place, more or less, since 1803 in over a hundred special acts of Congress. Between 1950 and 1969, special authorities were granted various Federal agencies to provide assistance in disasters, sometimes on their own statutory authority, and expanded when the President, under the Act of 1950, "declared" a "major disaster." A number of changes were added by executive orders as well as some special legislation as the result of successive disasters. The Camille disaster sparked the enactment by Congress of Public Law 91-79 which furnished a new panoply of aids to both the public sector and to individuals, the broadest array of disaster program assistance yet. But as broad as the law was substantively and retroactively, its time frame was limited to 31st December, 1970, when most of its provisions expire.

In short, while greatly amplified, the Federal disaster assistance program still consists of Federal assistance for specific purposes, whether meant for the public or the private sector. There is no language in the statutes which binds together the many separate programs into some unified policy statement that explicitly commits the Federal Government to the goals of social and economic rehabilitation of disaster stricken areas. Nor is it at all likely that such language will be introduced in the new legislation currently considered by Congress. Even though the present program made up of over 50 separate Congressional enactments and executive actions are likely to be consolidated in the current revised bill S3619, it contains no reference or commitment for long term recovery by the Federal Government following a disaster. The new bill includes a number of provisions that are clearly related to and imply a concern of the Federal Government for long term recovery without, however, accepting any general responsibility thereby. Included for example in revised S.3619 in referring to the development of State disaster plans is the statement, "Such plans should include long-range recovery and reconstruction assistance plans for seriously damaged or destroyed public and private facilities."

II. Within a narrow frame of authority, OEP has by its leadership made a start in providing assistance programs aimed at long-range recovery. However, before describing these programs, it will be of special interest to the reader to learn more of the social, economic and political back-ground that prompts this great spurt of interest in Federal disaster assistance at this time. He may well ask what are the conditions that have led to such intensification of interest in improving the US program? There are a number of factors, the most important being the big disaster of Camille. The sheer magnitude of the destruction visited on the Gulf Coast compounded by its unexpected passage through the valleys of Virginia and West Virginia with its heavy toll of lives dramatized the need of more effective preparedness and operational co-ordination. As we shall note, OEP ordered a systematic evaluation of all actions taken by Federal agencies in an effort to squeeze out of this experience whatever lessons could be learned for the future. The Hearings conducted by the Senate Special Subcommittee on Disaster Relief served to highlight the omissions and weaknesses of the Federal agencies' experience.

But one must not be left with the false impression that the change of attitude in the Federal program came overnight, or that it was due solely to the Camille Hurricane. As every student of history knows, man's propensity is to learn the hard way - after the fact - or to quote the American historian, Charles A. Beard, "When it's dark enough, you can see the stars." Not that "the stars" were seen perceptively as a single flash of insight, but rather that for a number of decades significant things were happening in the economy that Hurricane Camille brought into the foreground to make the time ripe for action. Let us list and discuss some of the dominant influences.

1. Perhaps as important as any was the growing realization that the cost in dollars of natural disasters was mounting at such a rate that even though most disasters could not be prevented, the government should do what it could to reduce their cost. The Federal Government has actively sought to reduce costs of flood damage by building levees in anticipation of floods and by reducing individual losses by a program of flood insurance. The total number of disasters occurring has probably not changed, but the cost in dollars mounted signigicantly. New homes and suburbs now dotted a countryside where only woods and farm lands existed before. The population explosion after World War II saw the nation's population increase from 132 to 300 million by the end of the century. One additional reason was the marked concentration of people settling in areas of favorable climates along the Coastal areas so often subject to tempestuous storms. The trend in increase of damage costs is unmistakable - not figuring 1969, natural disaster's most expensive year. According to Dacy and Kunreuther's "Economics of Natural Disasters," the annual cost in current prices increased from

$728 million in the five year average between 1925 and 1929 to $3335 million during 1960-1964. According to testimony presented by the insurance industry at the Camille Hearings, flood and tornado damage during the period 1960-1964 had increased by 250% since 1925-1929, and hurricane damage had increased by 1000% during the same period. It is not suprising then that there has developed a consensus that Federal Government's resources should be brought to bear on the problem.

2. It has been observed here that the rôle of the Federal Government initially was merely to extend supplementary disaster aid to local governments. Individual disaster assistance was regarded as the prerogative of voluntary relief organizations and private charity. Congress had in fact acted on that proposition by chartering the American Red Cross in 1905 to ameliorate private suffering. Exceptions were made to allow the Small Business Administration (SBA) and other Federal agencies to offer loans to disaster victims as low rates of interest. Not until 1965, however, in a special bill designed to assist the victims of the Southeast Hurricane in 1965, did Congress permit the government to help by cancelling a part of the principal of loan-up to $1800. It is part of the dynamics of disaster assistance that each level of assistance moves progressively higher, never lower.

3. For out purpose here it is necessary only to refer to the commonly accepted belief that the resources of the Federal Government are relatively boundless to understand why citizens in the United States "expect" their government to assist in event of need. By comparison with the States and local governments, it possesses unquestioned Constitutional authority "to lay and collect taxes." While many States have sought to increase their revenues by resort to income and sales taxes, the Federal Government has preempted the most lucrative and undisputed sources of revenue. The inference would seem almost as a reflex that if help needs to be provided, that the Federal Government should do it.

4. The changes in the Federal disaster assistance program could not have come about without there being developed an organization having the necessary authority and capability of accomplishing the task. To an unusual degree, this came about due to the co-ordination and leadership exercised by OEP under its Director, General George A. Lincoln. The changes in legal authority and organization were relatively minimal. The changes in concept and direction, on the other hand, were major and decisive. For almost twenty years, the OEP disaster program was almost exclusively "engineering" in concept. It dealt with road and bridge repair, debris removal, sewer

replacement, etc. - in short, "things" as contrasted to helping people. General Lincoln took the view as expressed in his own words, "The end purpose of Federal disaster assistance is to help people." From this viewpoint, OEP could no longer fulfill its disaster assistance responsibilities piecemeal, in limiting its function to the discrete pieces that came to it for funding in project applications. It was necessary to take the overall view, to see each major disaster as a whole; How did it affect the total area and its people, and what could the Federal Government do to help them? From this departure from precedent, it was but a minor inference to the conclusion that OEP disaster assistance could hardly stop short of the goal of long-range recovery. To accomplish this, it was necessary to develop an improved administrative organization.

III. The specific details of the Federal disaster program affecting long-range recovery is still in a state of development at this time of writing. The general outlines of the program that will emerge from the committees of Congress are probably well delineated, however. It seems at this time of writing fairly certain that a new "Disaster Assistance Act" is likely to be passed by Congress before the end of this year, but not until its final passage can one be sure of its detailed features. It seems certain, however, that the following elements of disaster assistance are already sufficiently established as to become part of the future recovery program:

1. Individual disaster assistance - Sixty-five years have passed since Congress chartered the American Red Cross as a quasi-officiel agency with responsibilities to ameliorate suffering as a result of disasters. Until only the last few years, it was accepted that, except for loans by Federal agencies, individual assistance should be dealt with by voluntary agencies and private charity. There is now an avowed recognition that giving the right kinds of assistance on a timely basis has a salutary effect in aiding an area's recovery. It is likely that the precedents established in the statute passed in 1969 will continue - such as loans with provision for cancellation of part of the indebtedness, unemployment compensation for loss of employment resulting from the disaster, temporary housing to be assured through improvements in organization and procedure, improved distribution of food stamps, etc.

Not less important are some of the improved practices learned from the Hurricane Camille, some of which have been successfully tried in the Texas disasters at Lubbock and Corpus Christi. Instead of having each relief agency or organization be located in different places as suited their convenience, all the individual assistance organizations are co-located to operate under a single roof in one or more "one-stop" centers. This not only makes possible improved co-ordination and supervision to make sure that the victims are properly cared for but avoids the needless frustations of fruitless searching and being **misdirected.** Where the one-stop centers cannot be located close enough to the disaster, provision has been made for transportation until such time as regular service is restored. OEP has made a systematic effort to correct two of the major criticisms at Camille: it has elicited the support of local community groups and other Federal agencies to reach out ("outreach") to bring information to disadvantaged and minority peoples about the assistance available, and also to see that their civil rights are not disregarded. At first glance, some of these procedural practices may seem somewhat remote from the objective of long term recovery. But the timely and adequate provision of food, shelter, clothing and the prevention of disease are the essence of what helps to create well being in a community.

The importance of the Federal loan program for long term recovery warrants special mention. Making long term loans at low interest rates by Federal agencies to victims of disasters for the repair and reconstruction of homes and business establishments has been a Federal practice since 1953. The importance of this program lies in (a) the extreme flexibility of the program, (b) the large amounts of money loaned that have a considerable economic impact as relates to recovery, and (c) the more recent feature of allowing cancellation of a portion of the indebtedness. The two principal agencies involved are the Small Business Administration (SBA) and the Farmers Home Administration (FHA), the latter concerned primarily with agriculturel enterprise and in rural areas of a population under 2500.

SBA which has the largest disaster loan program practices a remarkable degree of flexibility in loaning of funds, and has a wide range of discretion. There is no statutory limit to the size of the loans. Although the SBA prefers bank participation in making loans, it is not a requirement. Nor is it necessary for the applicant any longer to indicate that he cannot obtain funds through commercial channels. The size of the loans range from $500 and up to over a quarter of a million dollars on business loans. Unusual is the fact that not less than 85% of the loans requested are approved by SBA, with little variance between the amounts requested and the amounts approved. SBA works very closely with the American Red Cross in disasters, not only to avoid duplication, but to provide positive assistance for the victim. It is not at all unusual for example for the Red Cross to stake a victim with enough of a cash grant to provide collateral on an SBA loan. One interesting provision of the new Senate Bill is that in all disaster loans made hereafter no Federal agency may consider the age of the adult applicant in determining whether a loan may be made or the amount of the loan. Thus, senior citizens suffer under no penalty of age in applying for a disaster loan.

The amount of money that is funneled into a disaster area through the loan program may be large enough to have an immediate effect in reviving the economy. In the case of Hurricane Camille, the SBA reported having approved loans totalling almost $140 million, which in itself might turn the tide. The amounts will, of course, depend on the severity of the disaster in requiring home repair and building reconstruction. SBA reports loaning over $10,000,000 in each of six different disasters, from $1,000,000 to $10,000,000 in 21 disasters, and from $100,000 to $1,000,000 in 87 disasters.

The practice of allowing the loan applicant to cancel part of the loan obligation is more recent, having begun in 1965 after the Southeast Hurricane, allowing up to $1800 to be written off. This provision was again included in the 1969 legislation and also in the new Senate Bill, in which the cancelled portion is increased to $2500. The new bill also provides that existing loans held by the Department of Housing and Urban Development (DHUD) and the Veterans' Administration (VA), that extensions of time for repayment of the loan may be granted if the disaster circumstances warrant.

2. Prevention of disaster damage - For some foreseeable time, man may continue to lack resourcefulness to control and prevent the giant phenomena of earthquakes, hurricanes, tornadoes and floods. Only in the case of disasters which are not precipitous or instantaneous - disasters that can be predicted or prepared against - has man been able to take constructive action. While natural disasters occur with the same frequency and fury as in past years, the toll in lost lives has been greatly reduced by warning procedures and large scale evacuation from endangered areas. For example, the Corps of Engineers has built literally hundreds of miles of permanent levees that protect many of our large cities located in the river basins.

3. Permanent restoration of public facilities - Until this time, under the original Disaster Relief Act, Federal financial assistance was by law limited to "temporary repair and emergency replacement" of essential public facilities. The rationale for this limitation was

that Federal assistance was only "supplementary" for the purpose of affording quick restoration of their use, and that the legal responsibility reposed with the States and their local governments. In actual practice, however, when a public facility was severely damaged or destroyed, it was impracticable to make emergency repairs. A broken sewer for example had to be replaced by another sewer which in effect was a permanent, not a temporary replacement. Often there was a tendency to stretch the meaning of the qualifying adjectives and to grant permanent reconstruction where the law allowed only for a less amount. But on the other hand, in many cases, for example where flooding recurred, it was found that a "temporary" bridge made of untreated timber which complied with the law had to be frequently replaced, that could result in a greater total cost than if a permanent bridge was allowed in the first instance. The Disaster Relief Act of 1969 recognized the need for legally providing for permanent reconstruction of roads and bridges. If the States or local governments preferred replacement with a permanent structure, the Federal Government would provide 50% of the funds, and the applicant the other 50%. This provision for permanent restoration is retained in the new Senate Bill and has been broadened to include all kinds of essential public facilities. This in itself may be of less than epochal importance. But it is a constructive step forward in recognizing the need for thinking of replacement of public facilities for the needs of the longer future.

4. Fiscal assistance to local governments - One of the less known casualties of big disasters is the alarming state of local government finances, especially if the disaster has destroyed much of the real property in the community. Local government in the United States is almost totally dependent on real estate taxes, and if the houses and businesses are destroyed, the community has a reduced tax base on which to levy taxes. The Federal Government's disaster program assists to the extent that public facilities are repaired and restored to service. But until now, it has stopped at that point and has left the burdens of unsolved fiscal problems to be borne locally. Even without disasters, the student of American local government knows how precariously most cities' and counties' taxes hover on the brink of insolvency.

This problem was forcefully brought to the attention of Federal officials after Hurricane Camille when in their extremity, local government officials appealed for help. In truth, they had nowhere else to go, and if they could not obtain enough tax revenue until their tax base became restored, their long-range recovery might be permanently blighted.

As a result, Congress is seriously considering provisions in the Senate Bill which would establish a $100,000,000 Community Disaster Loan Fund which would provide long term loans to disaster affected communities if they had suffered a loss of more than 25% of their tax base or could not otherwise meet their obligations or perform necessary public services.

5. Use of emergency support teams - One of the concepts in Federal disaster assistance of relevance to long-range planning is the use of "emergency support teams" of personnel to be used in assisting disaster affected areas, an idea now incorporated into the new Senate Bill. The idea of using an emergency support team originated after the Camille Hurricane when a number of communities in Mississippi found their financial structures in dire straits without local expertise to try to find solutions. As a result of a request from the Governors' Emergency Council, four persons were selected from the OEP staff to work as a team with the officials of the State and six Mississippi communities. The problems of these communities were legion: a heavily diminished tax base, the pressures to reduce taxes and public services, the need to encourage present residents to rebuild in the same community, a desperate need for housing, the need to improve municipal facilities, and planning for long-range recovery. Some money was available from the State and some from local volunteer drives. But there was not nearly enough to accomplish all the pressing needs, and the local government officials, more than ever, needed expert counsel and direction to establish priorities. The Federal Government's assistance in the established disaster programs was already in effect. But since there were over 1200 other Federal assistance programs that were applicable, the local officials needed advice as to which of these were most applicable to their needs. After making a detailed analysis of the local financial condition of each city, its present and future revenues and absolute requirements, they arranged meetings with the representatives of the Federal agencies offering assistance programs. Some of these required matching funds, others which required less amounts of cash, and some advanced loans. A program was worked out in detail for each community based on the following priorities and needs: (1) Assisting local government; (2) assisting housing construction and business redevelopment; (3) improving basic municipal utilities and facilities; (4) the needs of long-range planning (more than three years); and (5) long-range development projects. Under each of these priorities, a list of specific Federal assistance programs that were most applicable was selected and recommended to the City Fathers.

Thus, began an interesting innovation which promises to have many future uses in long-range disaster recovery. In this particular instance, OEP staffers were found most applicable as an emergency support team. In other cases, depending on what kind of expertise is needed, it may be found expedient to borrow personnel from other Federal agencies. To the maximum extent possible it is considered desireable to enlist indigenous talent within the disaster area - or of its State to encourage self-help and volunteer effort, with OEP acting in a co-ordinating catalyst rôle. It may be noted that OEP assistance for the stricken Mississippi communities did not end with their submittal of a written report. There has been continued liaison and follow-up with acknowledgement of the assistance by the Mississippi authorities. While setting a precedent for this type of emergency team effort, it has also affirmed within the Federal establishment a recognition of a responsibility that its disaster assistance extends beyond the emergency period into recovery for the long term.

6. Assisting in improving building codes - It has been manifest here that disaster assistance takes many unexpected forms and from time to time leads the Federal Government into strange paths. One of the avenues in which Federal recovery programs has moved is the encouragement by whatever means of improved building codes and standards. It was apparent after Camille that the reason why many of the buildings were destroyed was that construction standards were inadequate to meet the requirements of high winds, and that structures were built at too low an elevation in case of high water. Matters of this kind are normally determined by building and construction codes. and zoning ordinances of local government. Camille proved all too tragically that these mistakes must not be repeated in the rebuilding of the area. The Governor's Emergency Council was given the responsibility of enforcing a new building code, and the co-operation of other groups, such as contractor's association, building trades, insurance industry and lending institutions was enlisted to employ the codes in all new construction. For example, all future construction in the Gulf Coast area must have a minimum elevation of 12 feet above high water. The rôle of the Federal Government in supporting improved building codes in disaster recurring areas can be considerable. Its importance is recognized in the new bill before Congress which provides that no home damaged or destroyed in a major disaster can be rebuilt with Federal assistance that does not comply with regulations which the Secretary of Housing and Urban Development is authorized to promulgate. Immediately following a disaster, teams of experts are flown to a disaster area to analyze damage in structures in order to make recommendations of how they may be improved by

changes of composition and design. In the long run, this may prove of telling effect in the reduction of damage.

7. Regional Councils - Among the improvements in the Federal agency field organization that may prove of considerable future importance to long range recovery programs are the new Regional Councils established by President Nixon in 1970. One of the problems that has long existed in the field organization is the lack of uniformity of regional boundaries of the Federal agencies which often found the regional offices serving the same areas located in different cities, which made policy co-ordination on related programs extremely difficult. This was resolved by establishing ten uniform geographical regions with common regional offices in ten major metropolitan cities. The program was instituted first with five Federal agencies all having important grant in aid programs and all deeply involved in problems of social and human engineering. These were the Department of Health Education and Welfare (DHEW), Department of Housing and Urban Development (DHUD), Department of Labor (DOL), Small Business Administration (SBA), and the Office of Economic Opportunity (OEO). In each of these regional centers, the President established a Regional Council made up of the Regional Directors who now meet regularly with a secretariat to discuss problems in common. Recently OEP was made a member of the Regional Councils by Presidential order, and the Council now is available under OEP leadership to be used to develop and co-ordinate programs of long-range recovery following major disasters. It is anticipated that in time, other Federal agencies' boundaries will also be standardized and their regional offices co-located. Another step forward in improving the machinery for co-ordinated effort in long range recovery programs.

8. Federal insurance program - The need for private property insurance for natural disaster hazards not now covered by insurance has been recognized for some time, and particularly for homeowners and small businessmen. Large corporations, because of their geographical spread and their total capitalization are generally able to assume a loss. But when a disaster destroys thousands of homes and small businesses, their owners, not covered by insurance have too little a margin of capital to rebuild on their own. With insurance, the risk taking is spread among millions of policy holders and each one contributes a little of the cost, and no one is seriously hurt. That is the condition that exists for windstorm insurance which is available from the private insurance industry at a reasonable cost. But the essential conditions necessary for marketability of insurance - a reasonably determinable frequency of occurrence and spreading or sharing of the loss - are not present for

other than windstorm damage. "Flood" insurance which covers all kinds of rising waters - hurricanes, tidal surges, tsunamis, and earthquake insurance are virtually unavailable because of their excessive cost. These natural hazards occur in relatively concentrated areas of ultra-high-risk exposure, and offer not even a potential spread of the risk. As the Administrator of the Federal Insurance Administration put it, "Property owners on the Gulf Coast wanted flood insurance but those in the mountains saw no need of it". A number of insurance companies learned to their sorrow that their losses exceed their revenues, and went bankrupt. It has been clear for some time that if insurance is to be made available for floods and earthquakes, that it will require some underpinning and subsidy by the Federal Government.

The specific details of the US Flood Insurance Program are detailed in a paper submitted to this meeting by the Administrator of the Federal Insurance Administration.

IV. It is evident from the above discussion that the Federal long term recovery program as it now exists takes many forms, and is still in a rapid state of change before it emerges into a more definitive program. Except for disaster loan programs that existed earlier, the Federal assistance program in just the past year has taken on a wide variety of individual assistance aids for the first time. These are justified not only as ameliorative emergency measures, but as helpful to the economic recovery of a devastated area. Each new disaster will inevitably produce its own problems and require new solutions. Whoever would have imagined, for example, that the Federal Government would have moved a whole town into Alaska because future earthquakes endangered its earlier location? Time and circumstances will likely determine the specific applications to which Federal resources will be put. As for the rôle of the States, their inability or unwillingness to support their legal responsibilities with dollars for disaster assistance will likely mean the substitution of Federal dollars as the only dollars available. This will be justified on the grounds that (a) without these Federal expenditures the economy of a devastated area may remain depressed or may not revive, or (b) that in any case, the dollar inputs of the Federal Government may sufficiently speed recovery to make its contribution "economic" and worth doing. Judging from the reports received from the hardest hit areas of Hurricane Camille, the industry has revived to a remarkable degree and the Federal Governments' dollar inputs have been justified. There exists, however, no detailed economic data studies to support the conclusion that the same number of dollars could not have produced a greater volume of goods and services if invested elsewhere; in terms of their multiplier effect or in terms of their marginal product. But, as indicated earlier, immediately after a disaster the human appeal to help one's fellow man transcends the professional economist's careful weighing of dollars agains product.

Whatever is included in the new legislation when Congress again meets, it is certain that the direction will not move backward but forward, and likely with increased momentum. The giant strides that have been made have set precedents.

From a program of meager beginnings in which the Federal Government could intervene only when asked for help, it now possesses an alert and dynamic organization that is beginning to set the pace for the country in terms of disaster preparedness. To the degree possible in natural disasters, it conscientiously attempts to initiate action to prevent loss of life and damage to property, and to anticipate the future. From a program that began as paying for pieces of damage within an engineering framework, the present program looks at the problems of a disaster area in their entirety and tries to help people after a major disaster by bringing them from where they are to where they ought to be. Americans are by nature pragmatists, and it is perhaps human nature to deal with the future only when it has become the present. But in the Federal disaster program there is exhibited a very real concern to be prepared for disasters wherever and whenever they occur.

FEDERAL DISASTER RELIEF ASSISTANCE

AN HISTORICAL REVIEW

by Field Operations Office, Office
of Emergency Preparedness (US)

FEDERAL DISASTER ASSISTANCE BEFORE PL 81-375

Red Cross and Other Private Efforts

Prior to the 1950 enactment of PL 81-875, there was no permanent program of Federal disaster assistance to State and local governments in the United States. Private agencies bore the primary responsibility for disaster relief. The most effective private disaster relief organization was the American Red Cross. Governmental sanction for the activities of this quasi-public institution is set out in the Federal code (36 USCA S.1.). Operating within the framework of this law, the Red Cross performed most relief functions to disaster victims. The Red Cross was usually able to provide short term assistance - food, clothing, emergency housing - and limited financial support for rehabilitation. In addition, it conducted rescue operations, evacuation, and mass care. These activities were aimed at the direct and immediate relief of the stricken population. By terms of its corporate charter, the Red Cross was not permitted to assist public sector recovery.

Private aid, in addition to Red Cross assistance, was largely non-existent in most sections of the country. Where other private relief organizations did exist, they were usually inadequate in the face of large-scale natural disasters. The narrow scope and focus of the Red Cross mission, the limited presence of other private assistance efforts and the limited budgets of all disaster aid organizations inhibited disaster recovery.

Local and State Governments

When disaster recovery assistance, in addition to that of private agencies was required, it was rendered by State and local governments. In the 19th century, local government services, in daily life as well as in time of disaster, were narrowly focused. Primary emphasis was centered on law enforcement. In time of disaster this included protection of citizenry and prevention of looting. As municipalities grew in size and complexity, all public services were expanded. Local government disaster response was broadened beyond law enforcement to include considerations of public health and safety. Later, as part of this evolutionary process, local governments assumed responsibility for repair of disaster-damaged public facilities - roads, streets, bridges and sewers.

This assumption of additional responsibility was compelled by necessity for maintenance of community economic activity and social fabric. Local governments were generally unable to meet these demands when confronted with large-scale disaster devastation. The narrow tax base of local government, and statutory limits on municipal bonded indebtedness, severely curtailed discretionary funds available for emergency disaster relief. These constraints often forced communities to make minimal repairs limited to the most important public facilities. Frequently, only partial resumption of public services was possible. In many cases public facilities were left in a state of disrepair for long periods of time (1).

States were also faced with disaster relief funding limitations, and they varied widely in the degree of disaster assistance offered to subordinate political subdivisions. Some States provided financial aid to disaster stricken areas from special emergency funds or from general contingency funds authorized by State legislatures. In other cases, State legislatures passed special legislation authorizing aid in the case of a specific disaster. Agencies of State governments occasionally supplied manpower and equipment for projects falling within the purview of their usual areas of operation. Even with optimum utilization of all available State and local resources, however, disaster relief efforts were not adequate.

The Federal Government

The only alternative to the limited assistance of private agencies and State and local governments lay in an appeal to Washington for special disaster aid. As early as 1803, the Federal Government recognized its responsibility for disaster assistance in cases where efforts of private agencies and State and local governments were not adequate to cope with disaster damage. Between 1803 and 1950 over 100 separate special assistance acts were passed into law by Congress. These laws were enacted only after disasters had occurred (2). The after-the-fact nature of this ad hoc legislation resulted in a time lag between catastrophe and Federal assistance, and hardship and suffering were experienced before assistance could be made available.

A number of Federal departments and agencies were, however, given specific statutory authority to render assistance in particular kinds of disasters, somewhat alleviating this situation. The Corps of Engineers, for example, has long had authority to undertake emergency repair of flood control works and to conduct rescue operations. Since 1934, the Bureau of Public Roads has assisted with financing repair and reconstruction of disaster-damaged highways and bridges of the Federal-Aid Highway System. The Reconstruction Finance Corporation was given authority to make disaster loans for repair and reconstruction of business facilities.

During the 1930's, a large amount of Federal disaster aid was channeled through such programs as the Civil Works Administration, Federal Emergency Relief Administration, Work Projects Administration, Public Works Administration, and Civilian Conservation Corps. These programs, while not primarily geared to disaster assistance, frequently gave effective disaster aid. Federal disaster assistance was not formally co-ordinated, however, and there was no continuous program of Federal disaster aid.

Federal Assistance Under Public Law 233, 80th Congress

Prompted by the need for continuing Federal disaster aid in the hurricane-plagued Gulf Coast and flood-prone areas along the Mississippi and Missouri Rivers, Congress, in 1947, enacted the first general disaster relief act, (Public Law 80-233, approved 25th July, 1947). The War Assets Administrator was authorized to transfer surplus Federal property to the Federal Works Administrator; in turn, he was authorized to lend or transfer this property to State and local governments to alleviate disaster impact. The Federal Works Administrator was authorized to work through any Federal agency or any State or local government. Federal agencies were directed to give this effort full co-operation. No special appropriation was made to carry out this Act. FWA was told to use funds available under Public Law 79-679 (Federal Excess Property Act) for the transfer of surplus or other excess property.

The Federal Works Administrator thus assumed responsibility for administering the Disaster Surplus Property Program. When a disaster of sufficient severity occurred, the FWA would recommend that the President invoke Public Law 80-233. Upon favorable Presidential action, the War Assets Administration was alerted to anticipate material requests from local governments. FWA and War Assets Administration processed these requests and arranged for property delivery.

Surplus property was gradually depleted, and it became evident that a program of Federal cash disaster grants to States and localities was urgently needed. The President began allocating money for disaster assistance from his general contingency fund. This informal grant program finally led to establishment of a continuing disaster relief fund. This was the forerunner of the first Federal disaster assistance authority (Public Law 81-875).

ENACTMENT OF PL 81-875, THE FEDERAL DISASTER ACT

Legislative Experience

On 30th September, 1950, the 81st Congress passed the Federal Disaster Act (Public Law 81-875). This law gives the President broad and continuing disaster assistance powers. Federal assistance is made available only for "major disasters" declared by the President. The law defines a major disaster as any flood, drought, fire, hurricane, earthquake, storm or other catastrophe in any part of the United States which, in the determination of the President(*) is, or threatens to be, of sufficient severity and magnitude to warrant Federal disaster assistance. PL 81-875 aid is directed principally at aiding the recovery of the public sector within a disaster area.

Under authority of PL 81-875, the President issued Executive Order 10221 on 2nd March, 1951, which delegated disaster relief administrative responsibility to the Housing and Home Finance Administration.

The 82nd Congress amended PL 81-875 liberalizing National Housing Act credits and authorizing emergency housing for victims of major disasters.

On 15th January, 1953, the President revoked Executive Order 10221 and issued Executive Order 10427, transferring PL 81-875 administration from HHFA to the Federal Civil Defense Administrator (FDCA).

Under Executive Order 10427, the FCDA was empowered:

- to direct and co-ordinate disaster relief efforts of Federal agencies.
- to draft disaster preparedness regulations for the President.
- to foster development of State and local disaster relief agencies.
- to prepare annual and ad hoc reports on disaster relief and related materials for the President's consideration and possible submission to the Congress.

Executive Order 10427 emphasized the supplemental nature of Federal assistance set out in PL 81-875. The Order stated specifically that Federal aid was not a substitute for disaster assistance efforts of State and local governments and private agencies. Federal financial support for disaster assistance was made contingent upon reasonable collateral State and local expenditures.

(* Emphasis added

The 83rd Congress enacted PL 83-134 on 17th July, 1953, further amending PL 81-875 to permit loan and donation of Federal surplus property to State and local governments for repair of disaster damaged public facilities and for individual rehabilitation. This law was passed in the aftermath of a 1953 tornado in Worcester, Massachusetts. The legality of distributing surplus Federal property to individual disaster victims was questioned during that recovery program. Public Law 83-134 which explicitly allows the distribution of surplus Federal property to individual disaster victims ended this debate.

Executive Order 10737 (29th October, 1957), amended Executive Order 10427, and produced further alterations in Federal disaster relief administration. The new Order established qualification procedures for States applying for Federal disaster assistance. It also set forth Federal administrative guidelines that would be followed in the granting of disaster assistance. The Order spelled out the kind and extent of Federal disaster relief offered under PL 81-875 and set out procedures for release of Federal disaster funds.

On 1st July, 1958, the President, by Executive Order 10773, delegated all functions previously administered by the Office of Defense Mobilization and Federal Civil Defense Administration to the new Office of Defense and Civilian Mobilization. Executive Order 10782, (6th September, 1958), amended Executive Order 10773 and changed the title of the Office of Defense and Civilian Mobilization to the Office of Civil and Defense Mobilization.

The President signed Pl 87-296 on 22nd September, 1961, and the Office of Civil and Defense Mobilization became the Office of Emergency Planning.

With the passage of PL 87-502 on 27th June, 1962, Guam, American Samoa, and the Trust Territory of the Pacific Islands were included within the definition of "State" and made eligible for Federal assistance under PL 81-875. (Puerto Rico and the Virgin Islands were included in the original law). This action made PL 81-875 applicable to all US States and possessions. PL 87-502 also authorized emergency repair and temporary replacement of disaster damaged facilities of State governments. Public Law 81-875 originally provided only for repair or replacement of public facilities owned by local governments.

Public Law 89-769 (6th November, 1966) amended PL 81-875, by including rural communities, unincorporated towns, and villages as eligible entities on whose behalf a State or local government might make application for Federal disaster aid. PL 89-769 delegated additional responsibilities to OEP, specifically:

- Authority to share costs of repair, restoration, or reconstruction of State, county, municipal, or other local government agency projects in the process of construction where damage is(1) the result of a major disaster and(2) the projects are related to navigation, irrigation, reclamation, public power, sewage treatment, water treatment, water-shed development, or airport construction. (Federal sharing is limited to 50% of eligible costs as determined by the Director, OEP, within limits incorporated in the Act).

- Statutory affirmation of OEP's authority to plan and co-ordinate all Federal disaster assistance and OEP responsibility for disaster preparedness liaison with State and local governments.

- Directed the OEP Director to conduct a study of ways to prevent or minimize loss of property, personal injury, and death from forest and grass fires. (The OEP Investigative Study of Forest and Grass Fires was submitted to Congress on 5th May, 1967.)

Shortly after Hurricane Camille struck the Gulf Coast in August 1969, Congress passed PL 91-79. This Act permitted the National Government to provide additional disaster assistance, particularly to the individuals affected by major disasters. Some of the key provisions of the law are that it:

- permits the Small Business Administration and the Farmers Home Administration to cancel $1,800 of a loan received for damage caused by a disaster;

- permits the President to distribute through the Secretary of Agriculture coupon allotments and surplus food commodities to low income households;

- authorizes unemployment payments to individuals unemployed as a result of a major disaster;

- authorizes OEP, acting for the President, to make grants to States and political subdivisions for purpose of removing debris deposited on privately owned lands or waters as a result of a major disaster;

- directs the President to appoint a Federal co-ordinating officer to direct and co-ordinate assistance after each major disaster;

- provides for financial assistance to States in developing comprehensive plans and practicable programs for assisting individuals suffering losses as a result of major disasters.

The US Congress is currently considering enacting another disaster assistance statute, as several provisions of PL 91-79 expire at the end of 1970. Indications are that the Federal Government will further expand its disaster assistance capabilities.

Organization to Administer PL 81-875

The Disaster Assistance Division of the Office of Emergency Preparedness (3) is responsible for direction and co-ordination of Federal disaster assistance programs delegated to OEP. It is located in Washington D.C. and reports to the Director, OEP, through the Office of the Director of Field Operations. This division evaluates and makes recommendations to the Director on State requests for major disaster declarations, negotiates Federal-State disaster aid agreements, and administers disaster funds. The Division assigns specific disaster relief missions to other Federal agencies for implementation and co-ordinates and monitors overall Federal preparedness efforts. The division is a focal point for communications on disaster relief matters between the OEP Director and regional offices. Also located in the Field Operations Office is the Operational Analysis Division. This office, established in January 1970, scrutinizes existing procedures, develops program improvements, and conducts pilot efforts in all aspects and phases of the Federal disaster assistance program. As a complement to the above functions, the Division co-ordinates disaster-related research and acts as a clearinghouse for all such research. Offices of the General Counsel, Administration, Liaison and Information lend active support to disaster relief operations.

There are eight OEP Regional Offices located throughout the United States (4). Each office is headed by a regional director with a support staff of approximately five professionals, including a regional disaster assistance co-ordinator. Considerable authority has been delegated to Regional Directors for co-ordination of Federal disaster assistance at the regional level (5).

Relationship of Federal Assistance to Local and State Governments

Federal disaster assistance is intended to supplement disaster relief efforts of State and local governments and private agencies. OEP and its predecessor agencies have consistently adhered to this concept when making disaster declaration recommendations to the President. In collaboration with the States, a schedule of minimum State and local disaster expenditures has been developed which establishes threshold-expenditures criteria which State and local governments must meet to be eligible for PL 81-875 disaster assistance. Governors requesting a major disaster declaration must certify that the requisite minimum amount of State and local funds had been spent for disaster relief purposes during the 12-month period prior to the request for the declaration (6). The size of the required expenditure varies in relation to the size of each State's financial base.

OEP regional offices provide guidelines for preparation and improvement of State and local natural disaster plans. These plans delineate responsibilities of State and local government departments and designate officials having specific disaster assignments. Regional offices hold periodic training and orientation briefings with Federal and State personnel charged with natural disaster responsibilities. Close Federal-State relationships are essential to success of the Federal Disaster Program.

Relationship of Federal Assistance and the Red Cross

The American National Red Cross, though not a Federal agency, works in close concert with Federal departments, including OEP. It avoids duplicating the functions of other organizations and Federal agencies. When a disaster occurs, the Red Cross assumes its traditional rôle, providing mass care and feeding, locating temporary shelter, and furnishing medical and nursing care for disaster victims. This initial effort is followed up with long-term rehabilitation and recovery assistance. Red Cross relief is based upon need, not loss. The close working arrangement between the Red Cross and OEP has been formalized in a Statement of Understanding (7).

Availability of Federal Disaster Assistance -

Disaster Assistance without a Major Disaster Declaration

US agencies can make certain Federal disaster assistance available to State and local governments without Presidential declaration of major disaster. For example, the Department of Defense can provide military assistance to prevent starvation, extreme suffering and loss of life when local resources are clearly unable to cope with events. The Corps of Engineers may aid in flood crises and the Bureau of Public Roads has clear authority to replace and repair disaster-damaged roads and bridges of the Federal Highway System. The Department of Agriculture, Small Business Administration, and Public Health Service have major disaster relief functions which are not dependent on a major disaster declaration. OEP co-ordinates relief activities undertaken by those agencies, whether or not a major disaster is declared.

Disaster Assistance Triggered by Major Disaster Declarations

A number of Federal agency disaster assistance programs are activated only following a major disaster declaration. After declaration of a major disaster, the appropriate agency head has full statutory authority to activate these programs. OEP serves as co-ordinator. OEP is also authorized under PL 81-875 to delegate specific relief tasks to other Federal agencies.

Special Legislation

In addition to the basic natural disaster legislation, Congress has passed a limited number of special acts to increase Federal aid in particular situations. This body of law includes amendments made in 1964 to the Alaska Omnibus Act; the Pacific Northwest Disaster Relief Act; and the Southeast Hurricane Disaster Relief Act of 1965.

1964 Amendments to the Alaska Omnibus Act (PL 88-451) (8)

This Act was passed to assist Alaska in its recovery from the 27th March, 1964 earthquake. The law liberalizes the original Alaska Omnibus Act. Federal contributions for highway reconstruction were increased from 50% to 94.0%. The Secretary of Agriculture was given discretion to compromise or release part or all of a borrower's indebtedness under programs administered by the Farmers' Home Administration (FHA). The Secretary was also permitted to refinance outstanding indebtedness of loan applicants who wished to repair or rebuild farm dwellings or buildings, or purchase new building sites. Power to compromise or release a borrower's indebtedness under REA programs was also granted. Additional assistance was provided through Housing and Home Finance Agency (HHFA) loans for public facilities and urban renewal projects. HHFA was authorized to purchase the securities of, or make loans to, the State of Alaska to a limit of $25 million to finance these reconstruction projects. The Small Business Administration was permitted to make loans with a 30-year maturity for dwelling repair and replacement.

Pacific Northwest Disaster Relief Act, 1965 - (PL 89-41)

During December 1964, and early in 1965, California, Oregon, Washington, Nevada, and Idaho experienced extensive property loss and damage from floods and high waters. By this Act, Congress appropriated a sum not to exceed $70 million for fiscal years 1965 and 1966 for repair and reconstruction of disaster-damaged highways, roads and trails. Amendment of the Federal-Aid Highway Act also increased monies available to the five States for development of forest roads and trails.

The Act directed the President, acting through OEP, to undertake a flood prevention study of the Eel River (9).

Southeast Hurricane Disaster Relief Act of 1965 - (PL 89-339) (10)

Heavy damage to Florida, Louisiana, and Mississippi, from Hurricane Betsy prompted the passage of PL 89-339 in 1965. Special measures, designed to accelerate recovery in these States, were concentrated on highway and public works reconstruction.

The Act authorized sale of government mobile housing units previously loaned to occupants. The Small Business Administration and Farmers' Home Administration respectively were permitted to cancel a part of the principal or waive interest in loans in excess of $500. At the borrower's option, he was allowed to cancel up to $1,800 of the loan or waive interest due on a loan up to $1,800 over a period not to exceed three years. The Small Business Administration was given authority to make loans to private schools, colleges, and universities without regard to availability of credit from private sources. The Secretary of Housing and Urban Development was directed to undertake a study of alternate for disaster assistance programs, including disaster insurance (including flood insurance).

MAJOR DISASTER DECLARATIONS

Introduction

From enactment of PL 81-875 on 30th September, 1950, through 31st December, 1969, the President made 321 major disaster declarations. (See Figure 1). Every State received benefit of this Federal assistance, as did Puerto Rico, the Virgin Islands, Guam, American Samoa, and the Trust Territory of the Pacific Islands. The District of Columbia is the only eligible jurisdiction which has not received 81-875 relief aid.

Many requests for major disaster declarations are not granted. From January 1953 to 31st December, 1969, 125 requests for major disaster declarations were refused because analysis indicated damage was insufficient to warrant a declaration.

Floods

Under PL 81-875, there have been 206 major disaster declarations for flood occurrences through 1969. This figure represents over 60 per cent of all major disaster declarations and includes those for floods alone and for floods accompanied by ancillary incidents, such as tornadoes, severe storms, and heavy rains. Up to that time only Maine, New Hampshire, Michigan, and South Carolina had not experienced major flooding disasters.

Earthquakes

Since enactment of Public Law 81-875, earthquakes have accounted for four major disaster declarations. Lack of a workable detection and warning system and the tremendous physical force associated with earthquakes causes this type of disaster to be particularly likely to be costly in terms of death, personal injury and economic loss.

Tornadoes

There are, on average, 643 tornadoes in the United States every year. Forty-three major disasters have been declared for tornadoes under PL 81-875. Tornadoes occur more frequently than other types of disasters. They are shorter in duration, however, and cover less area. Disaster recovery efforts required usually fall within capabilities and resources of State and local governments and private agencies. Also, private insurance coverage is available for tornado damage. An effective warning system, operated by the Environmental Science Services Administration of the Department of Commerce, is in operation.

Hurricanes

Hurricanes and associated events have produced 41 major disaster declarations. Sixteen States along with Puerto Rico, Guam and the Trust Territory of the Pacific Islands have received assistance in the wake of hurricane destruction. Some sites have been declared disaster areas as many as four or five times.

Special Disaster Experience by Categories

Thus far we have been concerned with prevalent types of disasters - floods, earthquakes, tornadoes and hurricanes. There are other, more unusual, catastrophes which do not fit these categories. A major disaster declaration is often justified in the case of these more exotic if less numerous incidents.

Forest Fires

Forest fires have produced five major disaster declarations, PL 81-875 funds were used to defray costs of labour, material, and equipment for fire suppression. Effective mutual fire protection agreements among States and with the Departments of Agriculture and Interior have minimized the need for additional Federal assistance.

Snow Storms

Major disasters have been declared on five occasions due to severe snow storms. PL 81-875 funds were used for snow removal equipment to open blocked roads and highways. Federal funds also paid for the purchase and transportation of feed for stranded livestock.

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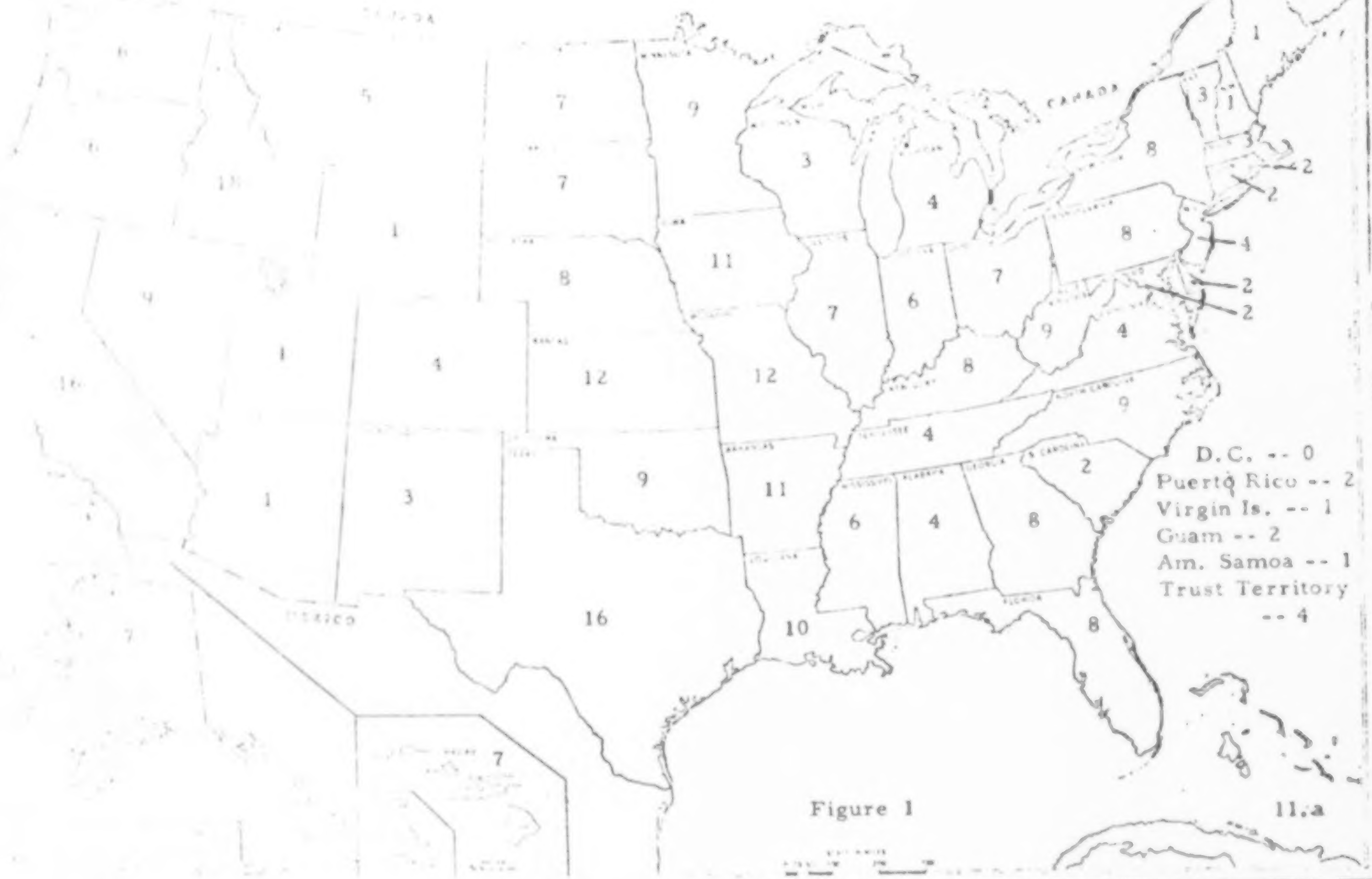
MAJOR DISASTERS DECLARED

September 30, 1950 -- December 31, 1969


CANADA
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D.C. -- 0
Puerto Rico -- 2
Virgin Is. -- 1
Guam -- 2
Am. Samoa -- 1
Trust Territory -- 4
11.a

Figure 1

Seismic Sea Waves

Hawaii has been hit twice and American Samoa and California once, by seismic sea waves of sufficient intensity to justify major disaster declarations. The California wave was caused by the Alaskan earthquake. Emergency assistance primarily involved clearance of debris and restoration of publicly-owned waterfront facilities.

Ice Storm

One ice storm produced damage of sufficient magnitude to justify PL 81-875 Federal assistance. The storm affected 21 counties in North Carolina in January 1968. Funds allocated for this disaster were expended to repair publicly-owned electric power transmission lines.

Reservoir Break

On 14th December, 1963 a break in the Baldwin Hills Reservoir in Los Angeles County, California, resulted in severe flood damage. The President declared a major disaster on 21st December, 1963. Because of advance warnings loss of life was remarkably low. However, public and private property damage amounted to many millions of dollars. OEP designated the Corps of Engineers to clear debris, and make emergency repair of streets, sewers and drainage facilities. A retaining fill was also constructed to prevent a potential landslide.

Chlorine Barge Incident (11)

On 23rd March, 1961, the barge WYCHEM 112, loaded with 1,110 tons of liquified chlorine gas in four pressure tanks, broke loose while under tow and sank in the Mississippi River below Natchez. A Corps of Engineers survey boat conducted a search shortly after the sinking but was unable to locate the barge. Other unsuccessful attempts to locate the barge were made over a period of several months. At the direction of the President, the Director of OEP designated the Corps of Engineers to find the barge and remove its hazardous contents. On 10th September, 1962, the Director delegated responsibility to the Public Health Service for public information and safety. The Service had earlier estimated that the chlorine could cause up to 25,000 fatalities should it escape. The President, at the request of the Governors of Mississippi and Louisiana declared imperiled parts of Mississippi and Louisiana major disaster areas. OEP assumed responsitility for overall direction and co-ordination of the recovery and removal effort and made funds available to eliminate the public hazard. The Corps of Engineers recovered the four tanks intact.

Droughts and Water Shortages

Eighteen major disaster declarations have been made due to damage from droughts and water shortages. Assistance rendered in each case varied with particular circumstances. A 1963 drought in portions of Vermont dried-up wells, reservoirs, and ponds, seriously affecting livestock. OEP financial assistance paid for transportation of 21.5 million gallons of water by tank truck to stricken areas. Puerto Rico and Virgin Islands droughts in 1964 saw PL 81-875 funds used to process and transport mixed feeds for livestock.

In a major drought disaster declared on 18th August, 1965, covering portions of a four-State area within the Delaware River Basin, OEP funds were allocated for construction of an emergency pump and pipeline system from a lake to a water supply basin. Other funds financed drilling and testing surveys to locate emergency sources of water and paid for studies of salt water intrusion into water intake areas.

CURRENT SITUATION

The Federal Disaster Assistance Program has served the nation well. It is a sound concept, effective in achieving its purpose, and widely accepted by elements of government and the public. Prompt and orderly Federal disaster assistance response is assured.

The Congress emphasized the supplemental nature of Federal disaster assistance. Care was taken to insure that the law did not conflict with disaster assistance responsibilities assigned other Federal agencies under seperate statutory authorities, or limit paralleling Federal disaster aid programs.

Congress has been largely relieved of the necessity for consideration of special assistance legislation for specific disasters. In cases where special legislation was passed it was due to the unusually catastrophic nature of the disasters at hand. Though these individual acts provided additional aid, they did not alter the basic administrative structure of Federal disaster assistance. They did not diminish OEP's major rôle as Federal co-ordinator. They tended, rather, to emphasize this rôle.

As originally envisioned, administrative responsibility for carrying out provisions of PL 81-875 was to be given to the Federal agency possessing technical competence relevant to the particular type of major disaster involved. This system would have rotated primary disaster assistance responsibilities through a number of agencies, with leadership passing from office to office as the nature of catastrophes varied. This would have produced conflicts between agencies with overlapping responsibilities, and might have left a vacuum in the case of "special" (unusual) types of disaster. This plan was never followed. Administration of PL 81-875 and subsequent disaster acts was permanently delegated to OEP and its predecessor agencies.

Until 1956, disaster assistance operations were conducted as an adjunct to regular OEP functions. No agency staff was committed specifically to disaster relief. This arrangement was adequate and sufficiently responsive until 1955, when the East and Northeast floods caused devastating damage over a six-State area. The end result was an unprecedented OEP disaster assistance effort (12). These events brought the need for a separate disaster assistance administration office into sharp focus. Such an office was established with the objective of planning for prompt and effective Federal disaster assistance reaction. The goal of this office is to maintain a high degree of flexibility to provide effective aid programs for both average and especially severe disasters. Close disaster preparedness liaison has been established between Federal agencies and their State counterparts. Disaster relief responsibilities of Federal agencies has been better defined and co-ordinated. Achievement of this improved disaster posture has been considerably aided by virtue of OEP's location in the Executive Office of the President.

The effectiveness of local-State-Federal teamwork for disaster recovery and rehabilitation has been fully demonstrated. The time has now arrived, however, when OEP is moving beyond a passive confrontation of disastrous events to an anticipatory program of active research in disaster management, and a comprehensive program of increased assistance to victims of disasters.

FOOTNOTES

1. Volume I, Legislative History, Federal Disaster Act, Public Law 81-875, 2nd Session, p. 47

2. Ibid. pp. 100-110.

3. This report discusses Federal disaster relief activities during the period 30th September, 1950 to 31st December, 1969. Public Law 90-608 approved 21st October, 1968, changed the name of the Office of Emergency Planning to the Office of Emergency Preparedness, the present name of the agency.

4. Locations shown in Federal Disaster Assistance Handbook for Government Officials; OEP Circular 4000.7, June 1968.

5. OEP Regional Operating Guide, Natural Disaster Program, OEP Order 4000.1, May 1963.

6. Report of the Joint Federal-State Action Committee to the President of the United States and to the Chairman of the Governor's Conference, Progress Report No. 1, December 1957, p. 7.

7. Statement of Understanding between the Office of Emergency Planning and the American National Red Cross Relating to Disaster Operations under Public Law 81-875, 11th August, 1966.

8. After-Action Report, Alaska Good Friday Earthquake, US Army Engineer Division, North Pacific by the Alaska District, January 1966, p. 31. Response to Disaster, Federal Reconstruction and Development Planning Commission for Alaska, Washington, D.C., September 1964, p. 21.

9. Report of Survey on Bank Protection Works Adjacent to Railroad along Eel River, California, US Army Engineer District, San Francisco, Corps of Engineers, August 1965.

10. Hurricane Betsy, Federal Action in Disasters, Office of Emergency Planning, Washington, D.C., 1966.

11. After-Action Report, Salvage of Chlorine Barge WYCHEM Sunk in the Mississippi River Near Natchez, Mississippi, US Army Engineer District, Vicksburg Corps of Engineers, Vicksburg, Mississippi, October 1963.

12. Report on Operation Noah, Corps of Engineers, (a) North Atlantic Division, May 1957, (b) New England Division, May 1958.

CCMS No. 2

FEDERAL DISASTER ASSISTANCE HANDBOOK FOR GOVERNMENT OFFICIALS

(This is the title of a booklet distributed in the course of the meeting. It deals mainly with assistance available after the President of the United States has declared a "major disaster". It describes also the assistance which may be obtained from federal departments and agencies where damages do not justify such a declaration. Additional copies of the handbook are available from:

Executive Office of the President,
Office of Emergency Preparedness,
WASHINGTON, D.C. 20504.)